

# *Railway Shop Up to Date*

## *Chapter III*

### **LOCOMOTIVE SHOP**

#### **THE SHOP BUILDING.**

**T**HE many prevailing conditions affecting the repairs of locomotives on a business basis, have brought about extensive changes in the buildings and equipment devoted to this class of work. Modern shops bear no resemblance to the antiquated structures once used for locomotive repairs.

While the buildings are free from expensive architectural embellishment, locomotive shops now are splendid structures, representative of the latest and most careful design, embracing stability, strength, natural lighting, heating, ventilating and sanitary requirements, and compare well with the facilities of modern industrial concerns.

Up-to-date locomotive shops are housed in brick buildings, in which the walls are tied to steel skeletons for stability. The roofs are supported by the steel skeleton structures and not only provide protection against the elements for men and equipment, but ample natural lighting.

The design of the locomotive shop building is made from an engineering viewpoint rather than an architectural one, and the details of placing machine tool equipment, erecting pits, provision of crane service and all auxiliary features, are as carefully planned for the particular purpose of the shop as are the details of a machine for a given class of work.

The practice at present is to build the locomotive shop with a clear height from floor to roof trusses, to provide for the operation of overhead traveling cranes and to offer no obstruction to natural lighting throughout the building, as well as to insure against shadows. In some instances a long narrow balcony, or gallery, occupies a position along one side wall and is located over a section of the main floor containing such machine tool equipment and minor departments as do not require continuous crane service. Such departments are then dependent upon windows in side walls for light.

Inasmuch as the buildings are long and narrow with usually at least three bays, the windows in the end walls provide but little light except at the extreme ends of the building and the windows in the side walls are at such distance from the central bay as to provide but little light therein. Therefore the most effectual buildings are those having side walls with windows extending nearly to the roof and in which the construction is such as to provide large windows above the roof of the lower bays to admit light to the higher bay. For instance, where the erecting floor is in the main, or central, bay such construction provides for large windows above the roofs of the side bays to admit light to the central bay, and a similar construction is modified to provide windows to admit light

above the roof of the machine tool bay when the erecting floor occupies the side bay.

In recent years the saw tooth type of roof has been largely introduced in locomotive shops to provide natural light. The tendency is to place the glass in skylights in a vertical plane or nearly so, in order to provide against the uncomfortable effects of the direct rays of the sun.

The most prominent instances of the use of the saw tooth roof are at the Topeka shop of the Atchison Topeka & Santa Fe, where such a type of roof is used over the two side bays containing the machine tool equipment; at the Sayre shop of the Lehigh Valley, where the entire roof is nearly flat and the inner bays are dependent upon the skylights for the principal daylighting, and at the McKees Rocks shop of the Pittsburgh & Lake Erie, where the two machine tool bays are on the same side of the erecting bay and where both of these bays are covered by the same flat roof at a lower level than the roof over the erecting bay.

The principal dimensions of the shop depend on the number and size of locomotives maintained and built per year, the class of work, and the amount of manufacturing done for shops along the line and for other departments.

As the latest design of locomotive shops has been confined largely to main shops, the examples of best practice are selected from among those erected for general and heavy repairs. It is the custom in some of these to build a few new locomotives each year, as such work provides an equilibrium of the forces, during periods of light and heavy work on repairs, and aids a satisfactory and permanent organization.

For locomotive shops it has long since been decided that the erecting and machine departments should be in the same building, but different opinions exist with regard to their relative locations and to the arrangement of pits. There are mechanical men who advocate arranging the erecting floor in two wings at right angles to the machine floor as at the West Albany and Depew shops of the New York Central. The arrangement of pits in one side bay and the location of machines in parallel side bays, as at the Angus shop of the Canadian Pacific and the McKees Rock shop of the Pittsburgh & Lake Erie, is preferred by others, while, still others prefer an arrangement with a center bay containing the erecting pits and machine bay on each side, as at the Topeka shop of the Atchison Topeka & Santa Fe and at the Du Bois shop of the Buffalo, Rochester & Pittsburgh. Attention is just now directed toward the plan of locating the machine bays between two rows

of transverse erecting pits as at the Sayre shop of the Lehigh Valley.

While several different plans have been mentioned, the prevailing shop construction indicates a preference for a long building with erecting and machine floors in parallel bays. Though there is a marked difference in the details of various shops, this feature is generally used in up to date shops, as securing the most intimate relation between the two departments.

The design and construction of several locomotive shops conceded to be representative of good modern practice, and erected in such sequence that their characteristics might justly be considered as tending to establish a precedent, embrace the boiler and tank shop within the same building as the erecting and machine shop. Such a locomotive shop is regarded with much favor among a large number of railway mechanical officials, but there are many, on the other hand, who prefer the boiler and tank shop in a separate building.

The most common arrangement according to the former practice provides for an assemblage of long narrow bays, within the limits of a single building, and the location of the boiler and tank department as a continuation of the erecting and machine departments without a definite division between them. Such an arrangement secures an extended scope for the use of traveling cranes, and allows a large area to be served without necessitating an excessive crane span. By locating the boiler department as an extension of the other two, a free use of the crane is available for transferring boilers, tubes, plates and other material, and by dispensing with a curtain wall, or other limitations of the boiler shop area, a more flexible arrangement of the shop is provided.

#### LOCATION OF BOILER DEPARTMENT.

The operation of large locomotive shops shows that in designing shops of this kind it is difficult to determine definitely how much space should be devoted to each department, and, as locomotive designs change, or as the motive power becomes older, or as the amount of manufacturing for other points on the road increases, one department is likely to become overcrowded. It is therefore considered expedient that the erecting, machine and boiler (including tank) departments should be so arranged that their limits may be changed readily to suit new conditions.

This practice, however, was not followed in the construction of the Louisville shop of the Louisville & Nashville Railway. The erecting floor is separated from the boiler department by a permanent curtain wall which determines absolutely the limits of each department. The wall is of such height as to permit continuous crane service between the two departments; but the management considers it more satisfactory to impose a limit to the floor space of each department.

At the Collinwood shop of the Lake Shore and Michigan Southern, while the boiler department is within the locomotive shop building, it occupies a side bay

and is not arranged as a longitudinal continuation of the other two departments. This shop is composed of four long narrow bays. The locomotive erecting floor and the boiler department occupy the outer bays, while the machine tool department occupies the two intermediate bays, with the heavier machine tool equipment in the bay nearer the erecting floor. Such a relation between the erecting floor and boiler department requires a greater amount of handling in the delivery of tubes, etc., between the two departments than obtains in a shop where both are served by the same crane and also requires a greater number of movements over the middle track connecting the departments and serving as the delivery track for locomotives.

#### PROPORTION OF DEPARTMENTS.

Of prime importance in the locomotive shop is the proper proportions between the various departments. In general, these are based on the locomotive erecting stall as a unit and the output of the shop is dependent upon the proper proportion of the other departments to so supply and promote work on the erecting floor that locomotives are repaired economically and returned to service in minimum time.

There is an evident diversity of opinion among railway officials regarding the proper proportions of locomotive shops. The areas of some recent shops are hardly indicative of best practice, in view of the additions to some departments which have been necessary in order to keep pace with the erecting department.

Principles upon which certain shops were designed, and the proportions based, have since been rudely upset by changes and developments in locomotive design. Greater steam pressures and larger boilers have increased the demands upon the boiler department, though, in some cases, this has been partially compensated for by the introduction of water treating methods which have materially increased the life of boilers; the introduction of cast steel in many details for which forgings were formerly used almost entirely, has affected the necessary size of the blacksmith shop by decreasing the demands upon that department; and the larger, heavier locomotives of today require greater machine tool equipment and more developed facilities for maintaining repairs.

In general, the machine tool area required to maintain locomotive repairs at minimum cost and maximum output, is considered to be at least fifty per cent larger than the area of the erecting floor. A shop equipped with from 6 to 8 machine tools per erecting pit might be expected to repair two locomotives per pit per month when operated with a good organization administered under a capable management. The output of the machines is the criterion, rather than the area of the department or the number of machines provided. The figures, therefore, are but approximate.

Generally speaking the required area of the boiler department is looked upon as being at least equal to the area of the erecting floor, and in many instances a boiler department 33 per cent larger is favored. The

proportion naturally depends upon governing conditions, such as the amount of new boiler construction, amount of work for other points on the road, character of water used, etc.

Considering the various factors involved in properly proportioning the departments as well as the conditions affecting locomotive repair work, it may be justly said that the size and standing capacity of the erecting floor does not limit the output of the shop. This limit is usually the machine space and machine tool equipment and by making them large in proportion to the erecting floor, a greater number of locomotives may be repaired per year on each standing space than could be turned out otherwise. The amount of work which can be obtained from one locomotive standing, or erecting space, is dependent upon the number of men employed and the work is flexible. If the machine space and equipment are not large enough to meet this demand, it is impossible to overcome this difficulty.

#### STORAGE OF LOCOMOTIVE SKELETONS.

A feature which should not be overlooked in connection with the locomotive shop is the provision of ample outside storage space for temporarily standing the skeletons of locomotives that are in the shop for firebox repairs. By placing the skeletons on special trucks and running them outside, while boiler work is being done, the machine work is taken care of at the same time and the frames, cylinders, etc., are not taking up valuable pit space which may be used to advantage by other engines.

#### NUMBER OF LOCOMOTIVE ERECTING PITS.

It has been said that good modern practice is to provide a number of locomotive repair pits equal to about 8 per cent of the number of locomotives to be maintained. However, information along this line is hardly conclusive and depends on a number of variable conditions.

#### ARRANGEMENT OF ERECTING PITS.

The arrangement of erecting pits, or stalls, for standing locomotives during repair work, is of much interest, though the selection of either the longitudinal or transverse system, seems rather one of personal preference than of actual advantage. While no conclusive evidence is available to show that a greater output is directly due to either arrangement, the selection of transverse pits for several shops on which construction work has been recently begun and for several others in which plans are now in preparation, would indicate that this arrangement is meeting with greater favor.

While earlier transverse shops required the service of a transfer table to facilitate delivery of locomotives to and from the several erecting pits, the introduction of overhead traveling cranes, capable of lifting and transferring the heaviest engines over others standing on the erecting floor, has so modified this requirement that there is a marked tendency to dispense with the transfer table as an adjunct to the locomotive

shop. At the same time certain experiences would indicate that the transfer table is being considered again with favor in some instances in which it had been once precluded.

Early transverse shops, not served by transfer tables, required a fan tail approach to the erecting pits, connecting with the system of yard tracks or with the roundhouse turntable, and while there are a few old shops with such an approach still in service, this arrangement is no longer used for new designs.

Before the introduction of traveling cranes, longitudinal shops required an entering track for each working track and it was necessary for a locomotive to remain on the same track on which it entered the shop, until repairs were made and the locomotive was ready for delivery.

With present facilities, a locomotive may be stripped on one track and later delivered to any desired working space on the erecting floor. When it is ready for delivery, it is again transferred by the cranes, and no confusion need arise on account of a locomotive being blocked by others not as far advanced in the stages of repair.

It is now the universal practice to serve an erecting shop in which the stalls are arranged longitudinally, by at least two cranes traveling on the same level and of such capacity that a locomotive may be lifted and transferred by both of them operating together. A crane of smaller capacity traveling on the same runways, is sometimes installed to serve the boiler department and thus relieve the larger cranes.

At the Silvis shops of the Chicago Rock Island and Pacific Railway an unusual arrangement of pits has been introduced. The direction of the working pits is neither transverse nor longitudinal but is diagonal.

This layout is known as the "herring bone" arrangement and provides for the erecting pits at an acute angle with a longitudinal pit traversing the center of the bay, on which engines enter the shop. From the entering track a locomotive is transferred to a repair pit by two traveling cranes. The angle of the pits should be such as would be made by an average length locomotive, hanging from the hooks of two cranes when the cranes are about to approach each other. Due to an error in laying out the pits at Silvis the actual angle is such that the cranes interfere and it is necessary to lower one end of a locomotive and swing the other end into place when the first crane has moved a sufficient distance to allow the second crane to approach. The inconvenience caused by this condition has not been serious enough to justify tearing up the pits and rebuilding them at the proper angle. The experience of the Silvis shop would indicate that while this error causes some inconvenience, it does not by any means condemn the principle of so arranging locomotive repair pits. The center track has no pit except at the ends of the shop beyond the end diagonal pits.

The erecting shop of the Pennsylvania Railroad at Altoona contains three longitudinal pits, each extending the length of the shop. The entire floor is served by two cranes of 130,000 lbs. capacity. Each side pit is served by three wall cranes of 4,000 lbs. capacity. Locomotives enter and leave the shop on the center track, on which they are unwheeled and stripped upon entering and rewheeled after repairs have been made. They are transferred from the center track to the desired location on one of the other tracks where they are dismantled and erected, by the two traveling cranes.

The length of the arms of the wall cranes is such as to serve both sides of a locomotive conveniently and at the same time there is sufficient space between the ends of these arms and a locomotive standing on the center track, to allow a locomotive, being transferred by the heavy cranes, to pass between the center row of locomotives and the wall cranes without interference.

Such an arrangement allows a free scope for the cranes in both light and heavy service. The work of one set of cranes is allowed to continue without limiting the operation of the other and the congestion of crane service sometimes experienced on account of the limitations provided by both sets of cranes spanning the entire width of the floor is obviated.

Transverse erecting shops served by a transfer table are usually served by one crane capable of lifting a locomotive for unwheeling and wheeling, as at the Burnside shop of the Illinois Central and at the Danville shop of the Chicago and Eastern Illinois. Such a shop is sometimes served by a crane of light capacity for handling the smaller parts and by a crane capable of lifting a locomotive for unwheeling and wheeling, but which is not capable of lateral movement and is dependent upon the lighter crane for transportation. This method is followed at the Baring Cross shop of the Saint Louis, Iron Mountain and Southern and at the Oelwein shop of the Chicago Great Western. At the Grand Rapids shop of the Pere Marquette locomotives are wheeled and unwheeled by a stationary electric hoist serving a single pit. The erecting floor is served by a traveling crane of 20,000 lbs. capacity.

In transverse shops not provided with transfer table service, the erecting floor is served by a crane operating at such height and of sufficient capacity as to lift a locomotive and transfer it above those standing on the floor, and by a crane of about 10 tons capacity, operating at a lower level, for handling the lighter parts, as at the Collinwood shop of the Lake Shore and Michigan Southern, the McKees Rocks shop of the Pittsburgh and Lake Erie, at the Sayre shop of the Lehigh Valley and others.

In a shop of this type, having 24 or more pits on one floor, operated to turn out more than two locomotives per month on each pit, the erecting floor should be equipped with two cranes on the upper level and each crane should be of such capacity as to transfer

the heaviest locomotive when the boiler contains three gauges of water and there is a fire on the grate.

Advocates of both long and cross shops advance arguments in regard to dimensions of buildings, floor area, etc., in favor of one arrangement or the other but either arrangement chosen should be selected on account of its advantages from an operating standpoint rather than with regard to original cost of construction. It is worthy of note that a long shop seldom contains the number of engines at which its standing capacity was originally rated when the shop was put into commission.

Both designs lend themselves readily to a desirable general layout as is shown by the ground plan arrangements of the Angus shops of the Canadian Pacific and the Indianapolis shops of the Big Four. The former is a long shop and the latter is a cross shop. Each forms a part of a layout which presents great similarity in many respects and each is tributary to a crane served runway.

Much argument has been presented with regard to the necessity of a turntable in connection with a cross shop, for the purpose of heading engines into the shop, unless the shop is situated transversely with the line of yard tracks. Practically the same argument obtains with regard to the longitudinal shop, for, if the shop is not parallel with the yard system of tracks, engines entering the shop must traverse a turntable or curve.

With regard to the choice between cross and long shops it is interesting to note that in the two most recently constructed shops on the Pennsylvania Lines East, Olean, N. Y., and Trenton, N. J., the former is a transverse shop while the latter is longitudinal, a fact which would seem to indicate that the preference is not determined even among officers of the same road.

Inasmuch as the choice in arrangement of pits seems to be largely a matter of personal taste, it is interesting to view the discussion of the report of the committee on shop layouts presented at the 1905 meeting of the American Railway Master Mechanics' Association.

The committee reproduced in part the work on this subject by Mr. R. H. Soule, published in the American Engineer, who was originally chairman of the committee. Following a discussion of the two arrangements, Mr. Soule sums up the situation briefly in nine items of comparison and, in totaling these several items, attributes greater flexibility to the longitudinal shop for general use. His summary may be expressed as follows:

Item 1. With regard to layout the longitudinal shop can be placed parallel to a general line of tracks and entered by direct track connections, while with the transverse shop, if placed parallel to a general line of tracks, it must be entered by a turntable.

Item 2. From a structural standpoint, the distance between roof trusses over erecting floor in the lon-

gitudinal shop can be determined by conditions of economy alone. In the transverse shop this distance must be the same as spread of stalls tracks whether economical or not.

Item 3. The longitudinal shop is less compact and the transverse shop more compact.

Item 4. Considering access from other shops, in the longitudinal, traffic must be across the pits. In the transverse shop it is not necessary to cross the pits.

Item 5. Lighting, both day and night, is more difficult in the longitudinal shop and in the transverse shop is easier and better.

Item 6. In lifting engines in the longitudinal shop, it is necessary to lift them only high enough to clear driving wheels, consuming less time, while in the transverse shop engines have to be lifted high enough to clear adjacent engines, consuming more time.

Item 7. In moving engines horizontally in the longitudinal shop less distance is covered under average conditions. In the transverse shop more distance is covered under average conditions.

Item 8. In dropping engines on their wheels in the longitudinal shop this work includes more use of cranes and less manual labor (in handling wheels), while in the transverse shop this work is done with less use of cranes and more manual labor.

Item 9. As a summary of these various points, greater flexibility is attributed to the longitudinal shop and less to the transverse shop.

In discussing these several items Mr. F. F. Gaines, then mechanical engineer of the Philadelphia and Reading Railroad, argues as follows:

Item 1. The first item may be stricken out from general consideration as it applies only to localities where the ground space is limited and governs a design rather than the general utility of the shop itself.

Item 2. From data given in report it is seen that the width of bays necessary with either class averages nearly the same, being 65½ feet for the longitudinal, 68 feet for the transverse with cranes on one level and 63¾ feet for transverse with cranes on two levels.

Item 3. Admits desirability of transverse arrangement.

Item 4. Admits desirability of transverse arrangement.

Item 5. Admits desirability of transverse arrangement.

Item 6. Lifting engines: Unless at all times the middle track of the transverse shop is kept open, or sufficient space between the tracks is left for standing an engine, it will be necessary to lift the engines over other engines, either to bring them in or take them out. If the middle track is kept open or space between the tracks is allowed it becomes a very uneconomical distribution of floor space. On the other hand, granting it takes more time to lift engines in a transverse shop, which is questionable, the amount of

such time is small and affects only a very small percentage of the force.

Item 7. For the same reasons as given under Item 6, it is questionable if it is at all favorable to a longitudinal shop.

Item 8. If the work is handled properly there is absolutely no difference in either system, in either time or manual labor.

Mr. Gaines adds two items not included in Mr. Soule's summary which cover the distribution of material. One refers to access to machines and movement of men to and from tool room and is very decidedly in favor of the transverse arrangement; and the other covers the storage of wheels, handling and storing locomotive parts during repairs, the transverse shop affording much more flexible arrangement as well as keeping the shop looking much neater.

Item 9, being a summary of various points for and against the two systems, would then appear as follows:

With Items 1, 2, 6, 7, and 8 equally favorable and Items 3, 4 and 5, in addition to the two items by Mr. Gaines, he considers the summary in favor of the transverse arrangement.

#### SIZE OF SHOPS.

The size of the shop is determined by the number of locomotives to be maintained and by the number which it is decided to turn out per year or per month. This determination is based upon the locomotive erecting or standing space as a unit, whether the arrangement of the erecting floor is on the transverse, longitudinal or diagonal plan. The past and present proportions of areas are hardly conclusive of best practice, yet to some extent they naturally form a guide for other shops under consideration, when sufficient data is available concerning the various governing conditions.

#### WIDTH OF ERECTING BAY.

In the longitudinal shop the distance between pits is an essential factor in the width (distance between crane columns) of the erecting bay. General usage has established three pits or tracks as common practice. In the earliest shops the distance between centers of pits was 18 feet and later 19 and 20 feet, until 22 feet is now considered the most satisfactory distance, though there are instances where this has been exceeded as at the Union Pacific shops at Omaha and the Atchison, Topeka and Santa Fe shops at Topeka, where the distance between centers of pits is 23 feet, and at the Angus shops of the Canadian Pacific, where the distance is 24 feet 9 inches.

In transverse shops, distance between pits naturally has no effect upon the width of the erecting bay. The governing factor determining the distance between pits is the same in both long and cross shops and depends upon the space required for workmen and for handling material, the location of work benches, the disposition of such parts of the locomotive as are not distributed to different departments and machines,

provision for storing cabs, and the use of portable machine tools on the erecting floor, etc.

The width of the bay in the cross shop is governed by the length of the largest locomotive likely to be repaired in the shop, the provision for an open passage way or aisle forward of the locomotives standing on the pits and of sufficient width to provide for handling boiler tubes in a manner that will not obstruct the passage way. The necessity for a bay wider than that to meet these requirements, depends upon the provision for the disposition of driving wheels. In some shops driving wheels are stored back of the engine to which they belong and on an extension of the pit and driving boxes are fitted to the axles while in this location. This is the practice of the Burnside shops of the Illinois Central Railroad, where the width of the bay between inner faces of crane columns is 74 feet 6 inches.

At the Collinwood shops of the Lake Shore and Michigan Southern Railway a comparatively narrow erecting bay is secured by a satisfactory provision for handling driving wheels. The tracks of the erecting pit extend into the adjacent bay and when wheels are removed they are rolled back of the engine into the heavy machine tool bay, where they are handled by the lighter crane, an arrangement which has the further advantage of relieving the cranes over the erecting floor. Wheels are handled similarly at the McKees Rocks Shops of the Pittsburgh and Lake Erie.

Sometimes engine trucks are repaired on the erecting pits in front of an engine, but this practice would not seem to justify its being a factor in widening the erecting bay to accommodate this work. It would seem more satisfactory to handle all truck work in a section reserved for this purpose, where it could be handled by a special gang repairing all trucks for the entire shop. Where this is not provided for, it would seem more satisfactory to repair the truck on the floor between the pits where it will not form an obstruction to movement up and down the shop and will not interfere with the erection of scaffolds and other provisions necessary in handling boiler tubes.

With cross shops the erecting bay is sometimes made wider than the requirement of the erecting department in order to provide for the location of a few heavy tools within the limits of the erecting bay where they can be served by the erecting floor crane. This practice is followed at the Danville shop of the Chicago and Eastern Illinois and to some extent at the Richmond Hill shop of the Long Island Railroad.

The greatest distance between crane columns in a longitudinal erecting bay, of which information is at hand, is in the shop of the Central Railroad of New Jersey at Elizabethport, N. J., where this distance is 79 feet 4 inches. The distance between centers of pits is 22 feet and the distance from centers of outside pits to crane columns is 17 feet 8 inches. This latter distance is greater at the Elizabethport shop than at the

other shops, and therefore necessitates a wider erecting floor bay.

The more common distance from center of outside pit to inner face of crane column is between eleven and twelve feet. Assuming 11 feet 6 inches as representing general practice and that 22 feet between centers of pits provides ample space for ordinary working conditions, it would seem fair to draw the conclusion that the width of erecting bay between faces of crane columns for longitudinal shops is 67 feet.

By examining the available dimensions of several locomotive shops having cross pits it is found that the maximum width of bay between faces of crane columns is 74 feet 6 inches, at the Burnside shops of the Illinois Central. This is an extreme case and is hardly conclusive of desirable practice. Wheels are stored behind engines standing on the pits, and between ends of pits and the crane columns is a wide passage way or aisle which at one time contained a standard gauge track, since removed. At one end of the shop, a portion of this space has been used for the location of a large wheel lathe within range of the erecting floor crane.

While the minimum is represented by the Chicago Great Western shop at Oelwein, and the Wisconsin Central shop at Fond du Lac, where width of bay is 57 feet 4 inches and 57 feet 8 inches respectively, an approach to a very satisfactory width of bay seems to have been determined upon at Collinwood on the Lake Shore and Michigan Southern Railway where this distance is 64 feet 2 inches. At the McKees Rocks shop of the Pittsburgh and Lake Erie very satisfactory results appear to be obtained with an erecting bay 60 feet 2 inches wide. The arrangement of erecting and machine bays at McKees Rocks is very similar to that at Collinwood, where there are two machine bays, both on the same side of the erecting bay.

It would seem then that a narrower locomotive erecting bay may be used to advantage with the transverse shop than with the longitudinal shop, though the difference is so small as hardly to be considered.

#### MACHINE BAY.

The practice of modern shops points to a custom of providing at least two machine tool bays. One bay is crane served and contains the majority of machines for heavy work, wheel lathes, tire boring mills, frame planers, slotters, drills, etc. The bay containing the heavy tools is naturally next to the erecting floor in order to minimize travel in delivery of material between erecting floor and machines.

The second bay usually contains lighter tools and is not often served by long distance traveling cranes. It is not unusual to find many machines in this bay served by traveling hoists or swinging jib cranes. The tool room and office are frequently placed in this bay.

In a number of modern shops the bay containing lighter tools is often entirely or partially covered by a gallery or balcony in order to enlarge the area of machine

tool space without increasing the ground area of the buildings as a whole. Such a balcony commonly contains machine tools for lightest service, such as brass work, light turret lathes, etc., and commonly the tin and copper smith departments.

#### AREA OF ERECTING FLOOR.

In cross locomotive shops the erecting floor area per pit varies in present shops of which information is available, from about 1,300 square feet to 2,288 square feet. This area at the St. Paul shop of the Omaha Railroad is 1,320 square feet; at Fond du Lac, 1,420; Reading, 1,523; Denver, 1,599; McKees Rocks, 1,598; Baring Cross, 1,500; Collinwood, 1,535; Sayre, 1,647; Oak Grove, 2,288. These figures are selected from large as well as small shops, and from old and new shops and indicate that the area of the erecting floor per pit does not vary according to the size of the shop, and while this area varies in different shops, it cannot be said either to have increased or decreased with the progress of time.

With longitudinal shops the area of erecting floor per pit varies from 1,667 square feet at Omaha, Union Pacific Railway to 2,000 square feet at Elizabethport, Central Railroad of New Jersey. There are so many shops in which the area of erecting floor per pit is about 1,700 square feet as to indicate that this ratio is satisfactory in long shops. The larger area noted at Elizabethport is due to the greater distance from outside pit to limits of floor than obtains in most shops.

At the Silvis shop of the Rock Island Railroad, which is arranged according to the herring bone plan, the area of erecting floor per pit is 1,910 square feet.

The number of peculiar governing conditions which enter as factors in determining the proportion between machine floor and erecting floor, renders difficult any attempt to formulate a rule governing this relationship. The relative proportions existing between these two departments and the demand for machine tool space generally felt at practically all shops, would indicate the necessity of a much larger area per pit for the machine floor than for the erecting floor. The figures representing the area of machine floor per pit are very similar to those representing the erecting floor, and vary from .85 to 1.5 of the area of the erecting floor per pit.

#### AREA OF MACHINE FLOOR.

Quotations from those shops just mentioned in connection with the erecting floor would indicate the trend in this connection. The machine floor area per erecting pit is as follows: St. Paul shops of Omaha Railroad, 1,426; Fond du Lac, 1,419; Reading, 2,123; Denver, 1,419; McKees Rocks, 2,340; Baring Cross, 1,365; Collinwood, 2,208; Sayre, 2,039; and Oak Grove, 1,294.

While none of the shops now in operation would warrant the conclusion, the experience of many shops for want of space would seem to justify a recommendation of machine floor area per pit equal to at least twice the erecting floor area per pit. The indications are that present erecting floor areas are sufficient to meet requirements. That greater machine floor space is required is

evident at many shops. A certain mechanical official expressed the opinion that present railroad shops lead him to the conclusion that the general tendency is to provide machine tool space entirely too small for the erecting floor and his recommendation would be three to one. Such an opinion is shared by others as well.

By concentrating a large number of men around a locomotive to push erecting and boiler repair work, rapid progress can be made when the finished material is available. Unless the machine work and that of the sub-departments can be made to keep pace with or ahead of the erecting floor, it would seem uneconomical to use a large number of pits as storage spaces rather than working spaces.

Where the practice is followed of inspecting engines before they leave the divisions to which they belong for the purpose of ordering necessary material in advance and thus be prepared when the engines arrive at the main shop, it is possible to push forward a certain portion of the machine work. This provides another factor which commends the larger machine floor area.

There is a difference of opinion concerning the number of machine tools which should be provided per pit in a locomotive repair shop. The argument in favor of increasing the machine floor area naturally refers to an enlarged tool capacity. At the same time, however, the general reference to machine space includes space provided for the several sub-departments which are maintained within the limits of the machine floor.

#### RELATIVE AREAS OF ERECTING AND MACHINE FLOORS.

Existing shops are not sufficiently alike in all details to determine a definite opinion or to allow specific conclusions to be drawn. Though the more recently constructed shops are much larger than the older shops and are designed to handle the larger power of the present, the relative size of the machine floor as based on the size of the erecting floor is not much larger than in the older shops and there is as much variation among the new ones as among the old.

A selection of several examples shows that the ratio of the machine floor area to erecting floor area varies from .65 to 1.66. Referring now particularly to shops which may be considered among the old ones built at a time when engines now looked upon as light represented modern power, it is interesting to note that the area of the erecting shop at Oelwein is larger than the machine shop and that the ratio of machine floor to erecting floor is .65. At the West Burlington shop of the Chicago, Burlington & Quincy and at the Bloomington shop of the Chicago & Alton these floors are of the same size.

Among the older shops remodeled to meet the conditions of the present date practice, the ratio of machine floor to erecting floor is 1.48 at the Omaha shop of the Union Pacific, and 1.8 at the Chicago shops of the Chicago and Northwestern. Considering some of the new shops built since 1902 there is as much variation as among those previously considered. This ratio is .87 at the Silvis shop of the Chicago, Rock Island and Pacific; 1.00 at the Danville shop of the Chicago and East-

ern Illinois; 1.02 at the Indianapolis shop of the Big Four Railway now under construction; 1.42 at the Collinwood shop of the Lake Shore and Michigan Southern; 1.43 at the McKees Rocks shop of the Pittsburg and Lake Erie, and 1.5 at the Topeka shop of the Atchison, Topeka and Santa Fe.

While these figures show that it is coming to be appreciated that a larger machine floor area is necessary, they do not indicate this fact to the same extent as is evident from the additions being made to some present shops. In most cases this addition is being provided for by a balcony or second floor. However, at the Reading shop of the Philadelphia and Reading additional buildings are being erected in connection with those already erected. Where the original erecting bay contained 103,600 square feet and the original machine bay contained 44,400 square feet, 100,000 square feet have been added by extensions, now making the total area of the machine bay 144,400 square feet and providing a ratio of machine floor area to erecting floor area of 1.39.

#### FLOOR SPACE PER MACHINE.

Because of the irregular sizes and shapes of the ground plans of the various classes of machine tools and the difference in the nature of the work handled, it is practically impossible to assign a definite amount of space per machine, even in proportion to the area occupied by the machine itself, that will apply to all machines. It has been said that for each machine the floor space required for operator, proper handling of work, etc., is very nearly equal to twice the area occupied by the machine itself, the area occupied by a machine being considered as equal to the product of its extreme dimensions, and that the floor space required in aisle room and general passageway will be approximately equal to 25 per cent more than the space occupied by the machine.

It is impossible, however, to formulate a definite rule which might be considered at all practical for all machines because of the many varying conditions which govern not only the location of the machine but the space which must be provided around it. It would seem, therefore, that the most practical method of arranging the machine tool layout is the old-time drawing-board method with pieces of paper cut to the same scale as the drawing of the shop floor plan. In following this each machine may be provided for individually according to the group in which it belongs and according to the class of work to be handled by the particular machine.

#### AISLE SPACE.

The provision for the movement and delivery of material is a very important factor in arranging the machine tool layout. Those shops which are operated most successfully are so arranged as to maintain an aisle extending the full length of each bay as an avenue for delivery, with transverse aisles at intervals, for transportation across the machine bay, to the erecting bay, or leading to a door connecting with the shop yard. Where sufficient space is not provided for standing material around each machine, such aisle space is infringed upon

to the extent of seriously obstructing and interfering with distribution of material.

#### GROUPING OF MACHINES.

The machine tool layout and arrangement of sub-departments of new shops and progressive changes in the older ones, together with the now more general practice of gang work, shows a keener appreciation of economy in working methods and increase in output obtained by grouping and specializing all work of the same class. This applies to the systematic grouping of machines in order that, after an engine has been stripped, the parts cleaned and delivered to a gang or sub-department, the various parts will require the least possible amount of movement while undergoing repair.

An example of such organization is manifest in connection with work on driving wheels, in which is included tires, journals, hub plates, driving box work, eccentrics, straps, etc. By locating near together the several sub-departments in which all such repair work is done, the movement necessary in advancing from one stage to the next is reduced to a minimum. It is now very common practice to pursue all wheel work on the machine floor, so that when a pair of driving wheels is returned to the erecting floor there is little more to be done by the floor gang beyond putting up the binders, shoes and wedges and connecting the motion work.

Therefore, by grouping machines and all necessary facilities the movement of wheels is reduced. This includes such location of large and small boring mills, wheel lathes, quartering machine, driving box equipment, tire setting equipment, etc., that there will be the smallest possible amount of movement of the several parts concerned after a pair of wheels has been delivered to the machine floor.

In both machine tool bays good practice indicates the use of swinging jib cranes and traveling hoists to facilitate handling material in sub-departments. For instance the movement of driving boxes to and from benches, planers, boring mill, drill, etc., and in laying out equipment provision is made to group the several machines in order to serve a specific sub-department, and thus minimize the travel of material.

In the heavier machine tool bay good practice is to serve individual machines and groups of machines by swinging jib cranes or hoists in order to relieve the traveling cranes. Planers are sometimes placed in bays not served by cranes, yet they are so situated that their tables may be run out under the crane of the next bay, so that they are practically crane served. This is noticeable at the Terminal Railroad Association of St. Louis shop at East St. Louis; McKees Rocks shop of the Pittsburg and Lake Erie; at the Danville shop of the Chicago and Eastern Illinois, and others.

In the Sayre shop, practically all machine tool equipment is under crane service. This is an excellent feature. However, the departments for rod work, motion work, air brake lubricators, gauges, etc., are under the gallery, and while this location is not dark in the Sayre shop, such a location as a general proposition does not seem

preferable in view of the nature of the work required at the benches.

At the Angus shops of the Canadian Pacific, there are two machine bays, both on the same side of the erecting floor. The wider bay, next to the erecting bay, is crane served throughout and contains the larger machine tools. The benches for motion work, rod work, air brake repairs, etc., are located in this bay. The benches are placed in the same vicinity, so that these several departments are practically grouped, and this arrangement commends itself as superior to placing benches for such work along walls, in corners, or in out of the way places.

Above the outer bay is a gallery in which the tin and coppersmith departments are located. The bay beneath the gallery is not served by a traveling crane, except in a small section, where engine truck repairs are made. Machine tools for lighter work are located in this bay.

The arrangement of machine tools in the Angus locomotive shop is representative of systematic grouping in order to reduce the cost of repairs and to increase the output of the shop. The machines are located in large groups, each arranged for a certain class of work. The machines for wheel work are located at the end of the shop nearer the midway. There is a wheel storage track beside the central supply track. Adjacent to this track on the erecting side are five wheel lathes and the quartering machines. The machine shop traveling crane covers this space and is used for placing the wheels in and out of machines. The wheel press is located at the end of the building in line with the lathes. This press is served by a jib crane attached to a steel column, and has a small electric chain hoist. The open space in front of the press is used for the setting. All the machines for driving and truck wheels, such as boring mills, axle lathes, milling machines, etc., are located on the other side of the central supply track.

The next group of machines is for cylinders, trucks and driving box fittings. There is a clear floor space for some distance, with lateral tracks and numerous jib cranes, supporting air hoists used for repairing engine trucks. The large cylinder planer and cylinder boring machine are placed in line with the wheel lathes and are served by the shop crane. Across the track are located machines for driving box fittings. The cleaning vats are placed in an addition just outside of the machine shop wall.

The next machines are the large frame planer, triple head frame slotter and multiple spindle frame drill. Across the track from these are machines for cross-head and piston work, as well as machines for lighter framework. The next group of machines consists of planers, slotters, milling machines, etc., for rod work. There are also a number of benches for fitting in this group. There are a large number of jib cranes in this section. The next group of machines is used for valve motion and general machine shop work. Following these are the machines and floor space for brake and

spring work, scale repairs, air brake work and steam-pipe fitting.

The rest of the main floor of the machine side is taken up with machines for boiler work. The first part has the flue department, with the regulation machines and furnaces, and a chain wet flue rattler. The latter machine is of interest on account of the small amount of time required in changing flues. This work has been accomplished in six minutes. The other boiler shop machines are arranged on either side of the central track to the end of the building and include a number of hydraulic punches and shears, as well as those driven by motors. This section has a large number of jib cranes with chain hoists, driven by air motors. The hydraulic pump and accumulator are located in the corner on this side of the building. The hydraulic riveters, of which there are two, one with 17 ft. gap and one of 6, are located at this end on the erecting side, where fitting up boilers and tank work is done.

In the gallery are located the small machines of all kinds for light work, including a tin shop, bolt department, brass work, tool work, etc.

#### STORAGE OF DISMANTLED PARTS.

Provision for the storage of dismantled locomotive parts which are not delivered to special repair departments or to some of the various machines is a very important consideration. The practice of providing pits beneath the floor, with movable covers, for the storage of such parts has generally been looked upon with disapproval, and this method is now seldom installed.

Several shops have used a specially designed rack on which the parts are stored while an engine is in the shop, and this arrangement has proved very satisfactory. In some instances a plan adopted provides for storing the cabs on this rack, supported by specially designed arms. This arrangement has not proved successful, and it would seem more expedient to store the cabs outside of the shop and preferably in a space served by an outdoor crane in order that they may be handled at minimum expense.

At the Louisville shop of the Louisville & Nashville Railway provision for dismantled parts is made in a very satisfactory manner by a platform supported by the columns between the erecting and machine bays. This platform extends from one column to the next throughout the length of the erecting floor and is carried at such height that it does not interfere with transportation or passage between the two bays. By storing these parts above the floor they are kept out of the way, and not only located where they are not susceptible to damage, but are also placed where they will offer no obstruction on the floor.

In addition to this platform, lockers are placed by each post and all small material, boiler fittings, cab appliances, etc., are placed in these lockers until such time as they are replaced on the locomotive from which they were removed. As soon as an engine is dismantled, all parts requiring repairs are distributed to the various departments. After repairs have been made these parts are

returned to the erecting floor and stored on the platform or in the lockers and are not allowed to obstruct any part of the shop. The platform is so situated as to be served by the erecting floor crane. Those parts not requiring repairs, such as brake rods, beams and levers, hangers, column brackets, pipes, hand rails, casings, jackets, etc., are stored on the platform as soon as the locomotive is dismantled.

#### SANITARY REQUIREMENTS.

In considering the sanitary requirements of a shop a number of peculiar features enter into the determination as to the most desirable facilities to be provided for the convenience and comfort of the men. While the statement in this connection might seem extraordinary, the amount of facilities required depends, like a number of other features in shop design, upon the organization.

The facilities provided in modern shops vary as to the number of each item provided per 100 men. From information gathered at several shops it is found that the number of wash basins per 100 men varies from 7 to 33; closets, 8 to 32, and urinals, 3 to 20. While these figures vary to such an extent as to be hardly sufficient to warrant conclusions, the following would seem to be a reasonable provision per 100 men: 33 wash basins, 15 closets and 10 urinals. Many of the men do not stop to wash up carefully before leaving the shop, and it is fair to assume that at least three men can use the same basin. It is preferable to provide ample closet and urinal accommodations rather than not enough. It has been said that the introduction of piece work at a certain shop reduced the necessary closet facilities about 50 per cent.

The experience of a number of shops in which the best kind of plumbing was installed would suggest the query as to whether such facilities are thoroughly appreciated. It is believed that the men are better satisfied with good and healthful ventilation than with elaborate fixtures.

Such thorough ventilation may be provided with modern equipment that many shop managers approve of locating all toilet facilities within the building. This not only removes the necessity of men going out of the building during working hours and provides against their going out of doors ill clad during cold and stormy weather, but further removes an opportunity for them to go beyond the observation of the foreman.

Some officials approve of placing a number of urinals at various places of convenience about the shop where they may be screened from view. This arrangement has the advantage of providing accessible conveniences without the necessity of a long walk where the shop is large.

In the locomotive shop building at Silvis there are four lavatories so disposed as to serve four territories of about equal areas in the shop. The lavatories are located on balconies. At the Angus shop the lavatory is in a wing of the building, or lean to. At the Collinwood shop it is on the ground level, in a position near the center of the shop. At McKees Rocks it is on a balcony.

The most comfortable arrangement of lockers is the provision of one locker for each man, though not infre-

quently two men occupy the same locker. Best practice indicates the more general use of metal lockers so constructed as to permit a free circulation of air and to provide for easy inspection to guard against the accumulation of inflammable material.

At Silvis the lockers are grouped beneath the balconies in which the lavatories are located. These are placed within an enclosure and access thereto may be had during certain hours only. At other times it is necessary to secure admission from the foreman. At Collinwood the locker room is on a balcony above the lavatory. At Sayre the locker room and toilet facilities are on the balcony, and it is found that the men are not favorably inclined to such a location for the lockers.

In a few shops the toilet facilities include shower baths.

The new shops of the Brown Hoisting Machinery Company have been equipped with shop toilets of new design which seem practicable and serviceable. The design comprises a series of stalls, or compartments, separated by concrete steel partitions of the Ferrocim construction, attached to light angle supports covered by one concrete steel hood. This hood is also of Ferrocim construction and runs to an apex at about an equidistance from either end partition, and which apex is a ventilating pipe. With the exception of the two ends, the partitions do not extend up to the hood, thus giving sufficient air circulation. The hood extends out over the doors.

The doors are hung from light angles, which extend across the partitions. These doors consist of steel plates rolled in the form of semi-cylindrical shells, and are hung from the top instead of from the side, being so adjusted that in rotating on rollers they describe the path of a cylindrical shell about its vertical axis.

Among the advantages claimed for the design are: A saving of space (practically three feet being saved by this door) over the ordinary side hinged style, in a sanitary way, the excellent hood or ventilating system, taking away all odors, and the concrete walls allowing easy cleaning with a hose. The interior is at all times closed to the outside view, thereby making it practicable to erect the same at points in a building that would be too exposed for the types of closets in ordinary use. It can readily be seen by the door whether a closet is or is not occupied. A closet cannot be occupied without the door being out. This fact, together with the lack of light and the partitions, is the means of a great saving in time, in that it eliminates the usual causes for the men loafing.

#### SYSTEMS OF ELECTRICAL DISTRIBUTION.

The systems of motor driving now on the market providing speed variations electrically have been worked out with a great deal of ingenuity, and all of them have some points in their favor for certain classes of service.

The problem before the railroad repair shop, however, is peculiar, and has certain features which are not common to any other line of manufacture. The success or failure of any system in a railroad repair shop will depend largely upon the simplicity and reliability of the

system for obtaining a given result. Railroad repair work, in general, is not susceptible to such great refinement as are certain lines of manufacture which duplicate standard parts indefinitely, and for this reason a system of distribution adapted to the needs of the repair shop must be flexible.

It is also important that, as far as possible, the system be capable of sub-division, in so far as the generating units are concerned, due to the fact that considerable overtime work is necessary, and at such times it is desirable to shut down parts of the generating equipment, operating only such machines as necessary.

There was a time, a number of years ago, when the railroad shop was extremely conservative in the matter of taking up new ideas, and was probably working to less advantage than any manufacturing establishment, for the reason that railroad repair work is practically devoid of competition. Some of the railroads have been extremely progressive in adopting new methods of production as applied to repair work, and they have virtually set a pace which must eventually be followed by the others. This will be more true as reliable reports of the better results obtained by the use of modern machinery and methods become public.

Second only in importance to the rapid production of work is the economy and reliability of the installation. Economy in operation means a reduction in the capacity of the engines and boilers operated in the power plant, and should also logically include the cost of maintenance and repairs to the apparatus installed.

Third in importance is the question of cost. Before any particular system is installed, complete costs should be obtained, including not only the cost of the machinery proper, but also the cost of wiring and special fixtures which in many cases constitutes a very appreciable percentage of the total cost of the installation.

Next in importance is the matter of simplicity. The average mechanic to-day is not a skilled electrician, and the installation of apparatus which is so simple that it may be maintained by the operator will save much time on the part of the regular repair man, who is usually busy with more important duties than the maintenance of individual motors throughout the plant.

In many cases individual drive will be found desirable, particularly for the larger machines, such as wheel lathes, frame planers and slotters, boring mills, axle and crank pin lathes, and in general machines doing comparatively heavy work. For the lighter machines, the group drive seems to be preferable, chiefly on account of its smaller cost. It is not the intention to discuss the relative merits of the individual and group drive to any considerable length. It is deemed desirable, however, to call attention to the fact that the individually driven tool is capable of being used independently of the rest of the equipment, and that, when so operated, it calls upon the power plant for only the power necessary to supply the driving motor. In making an installation it is usually possible to arrange for such a combination of group and individual drive that, when it becomes necessary to work

part of the shop equipment overtime, there will be operated, as a rule, only the tools required for the work in hand.

Broadly speaking, the various systems of electric driving which admit of speed variation applicable to machine shop work are as follows:

- (1) Multi-voltage systems;
- (2) Double commutator systems;
- (3) Systems in which the speed regulation is obtained by means of field control on one or two voltages; that is, a 2-wire single-voltage system or a balanced-voltage 3-wire system.

#### MULTI-VOLTAGE SYSTEM.

Considering first the multi-voltage system, it may be stated that this method, in general, consists of a number of wires between which various voltages may be obtained, the differences in voltages being produced by means of a series of boosters, or motor-generator sets, in combination with the main generator. This system originally involved the use of the following voltages: 40, 80, 120, 160, 200 and 240, and required for its distribution four wires. For the reason that the horsepower output in a given motor is practically proportional to the horsepower input, it is evident that the lower voltages, in order to transmit a definite horsepower, the current must be quite large as compared with that required at the higher voltages. This being the case, considerably larger conductors will be required for a given horsepower transmitted at the lower voltage than would be the case were the voltage maintained at a higher value. For this reason, as stated elsewhere, it is essential that the cost of the wiring be carefully considered before the multi-voltage system is adopted.

One of the principal characteristics of the multi-voltage system is due to the fact that the horsepower which may be developed by a motor increases directly with the voltage impressed on the armature terminals, the field strength remaining constant. This can be stated in another way, which may tend to bring out some interesting information relative to motors operating on the multi-voltage systems, under the present scheme of normal ratings adopted by the manufacturers of multi-voltage apparatus, the horsepower delivered by the motor decreases directly with the decrease in voltage from about 120 volts to whatever voltage may be called the starting voltage of the system. Since, in machine tool work, approximately constant output is demanded of the motor, it can be readily seen that, as the capacity of the motor decreases, the amount of the metal which can be removed decreases, and with it the value of the extreme range of speed variation; for speed variation in itself is of no value; it must be accompanied by the ability to operate the driven tool at its maximum capacity at all points within the limits of speed range claimed for the multi-voltage advocates, making approximately 1 to 3 and 1 to 8 in speed variation which are made by the system. This condition will qualify the claims of 1 to 10 the effective working range, unless the motor is abnormally large, and but a fraction of its possible output

is utilized at the higher speeds. It is essential that the purchaser of a variable speed motor obtain a continuous horsepower output over the entire speed range claimed for the motor, in order that he may be fully informed as to its suitability for the work in hand.

One of the advocates of the multi-voltage system has made the statement that 1 to 3 variation in speed is sufficient for machines requiring a constant horsepower output, such as lathes, boring mills, milling machinery, etc. It should be noted that this is the maximum speed range possible with the multi-voltage system, using as a minimum voltage about 120 volts, which is the lowest commercial voltage at which power may be generated, distributed and utilized without making the size of feeders abnormally large. For machines involving a reciprocating motion, such as planers, slotters, etc., the same manufacturer has made the statement that the horsepower increases directly with the speed. This statement is incorrect, for the reason that if the machine tool be worked anywhere near its capacity, the horsepower at the tool actually increases with a decrease in speed, within the working limit. Adding to this the increase due to the greater friction of the machine itself, it will be found that on machines involving reciprocating motion the horsepower required at the varying speeds will not fluctuate greatly. For this reason it is evident that the multi-voltage system as applied to machine tools should only be used throughout such a range of speeds as will permit of constant horsepower being obtained at every speed. In fact, this point is now realized by the manufacturers of multi-voltage apparatus to such an extent that one of them has made the statement that the lower voltages are to be used "for starting and light cuts only." It is a remarkable fact that the advocates of the multi-voltage systems are gradually abandoning the lower voltages and tending toward a single, or at most, two voltages in combination with field control, with a corresponding decrease in the total variable speed range, and a corresponding increase in the range of speed permitting constant horsepower to be taken from the motor. Thus one manufacturer has abandoned 40 and 80 volts, while the second has abandoned 60 and 80 volts and is now using 90 volts as a minimum. In both of these systems the intermediate speeds are obtained by means of field control—thus tacitly approving of this method of obtaining speed variation.

The controller used in connection with the multi-voltage system must handle a number of voltages, in addition to the field current, and is of necessity more complicated than would be the case were the machine operated on a single or two voltages.

#### DOUBLE COMMUTATOR MOTORS.

The use of double commutator motors has been limited, more or less, to the operation of printing presses, in which service the horsepower varies approximately as the speed; in other words, the minimum speed requires the minimum horsepower.

The construction of the double commutator motor involves the use of one commutator on each end of the

armature. The armature windings connected to these commutators may comprise either the same number of turns or a different number of turns, the principle of operation remaining the same. As the speed of a motor on constant voltage depends upon the number of turns in series in the armature, it is evident that by connecting both of these commutators in series, the number of armature turns may be increased, thereby producing a slow speed. As it is desired to increase the speed of the motor, one of the sets of windings in series is cut out, and, on one system, the speed is further increased by connecting the two commutators, so that the two sets of armature windings having a different number of turns oppose one another. The characteristics of the double commutator motor may be fairly represented by the performance of an ordinary motor on the multi-voltage system, in which the horsepower increases approximately with the increase in speed, but as a rule the controller used in connection with the double commutator machine is extremely cumbersome on account of the numerous functions which it has to perform, that is, connecting the commutators in series, connecting them to the circuit individually, and finally connecting them in parallel, and, in addition to this, the field current must also be varied for the purpose of obtaining the intermediate steps in speed.

One of the principal objections to the double commutator motor for machine tool driving is that, where the double commutator motor is used, the overhang from the center of the motor frame to the point of attachment of the pinion, if the machine be gear driven, is considerably greater than would be involved were the commutator, and consequently the extension of the bracket on the pinion end, absent. The importance of a rigid frame, with the point of application of the pinion for gear driving as close to the point of support at the base of the motor as possible (this distance being measured perpendicularly to the shaft), cannot be overestimated. Gears have imposed upon the shafts, bearings and end brackets of motors much more severe conditions than they ever encountered when belt drive was used, and this is a feature which is well worthy of careful consideration in installing motors for individual drive.

A second objection to the double commutator motor is the duplication of perishable parts, such as the commutator and brushes. While the renewal of brushes in a properly designed and well constructed direct current motor should not of necessity be very frequent, at the same time the double commutator motor doubles the opportunity for wear. The rear brushes, that is, the brushes on the pinion end, will very frequently be found more or less inaccessible, for the reason that the pinion end of the motor is frequently crowded closely into the machine tool, and it is the opinion of one of the largest machine tool builders in the country that this constitutes one of the principal objections to the use of a motor of this character.

This system has without question some advantages over the straight multi-voltage system, but the fact that double commutator machines have been built for a num-

ber of years, and that these machines have not come into general use, indicates possibly better than any other argument the feeling of machine tool builders and manufacturers as regards this system.

#### THE ALTERNATING CURRENT SYSTEM.

Because of the ease with which alternating current may be transformed either in voltage or phase it presents many advantages over any other system of distribution. Long distance transmission may be effectively accomplished by means of the alternating current.

The alternating current motor is peculiarly adapted to severe service, and for driving line shafting, or individual machines, the speed of which may be changed by mechanical devices, gives all the advantages obtained by the use of electrical distribution in general, together with a motor which is the acme of simplicity so far as mechanical construction is concerned. The absence of commutator and brushes contribute to produce a motor on which the maintenance is extremely small, and many large installations are now operating by means of alternating current motors exclusively.

The alternating current motors may be used in connection with direct current motors, both alternating current and direct current being obtained from a single generator, or from rotary converters, and it would not be surprising if the mixed systems became quite common for industrial and railroad plants. In the railroad shop installations now in service the main generators are of the polyphase alternating current type, direct current being obtained by means of rotary converters of the 3-wire even voltage type. These rotaries possess all of the advantages of the 3-wire generators, giving a 3-wire even voltage circuit from a single machine, using highly efficient stationary balancing coils in place of the wasteful motor-generator balancing units.

#### SYSTEMS IN WHICH SPEED VARIATION IS OBTAINED BY FIELD CONTROL.

Referring now to the third general division, that is, systems in which the speed variations is obtained by field control: There are on the market to-day a number of manufacturers advocating this means of speed variation. The system involves the insertion of resistance in the shunt field of the motor, and while the general scheme used by different manufacturers is the same, the details have been worked out differently by the various companies building machines of this class. One manufacturer uses a so-called reaction winding, the purpose of which is to neutralize the armature reaction. This method has in its favor the possibility of considerable range in speed on a single voltage, while on the other hand, it involves considerable complication in construction, as compared with the ordinary motor.

A further objection to this construction is that this reaction winding interposes in the armature circuit considerable resistance, and the introduction of resistance in the armature circuit has always been accompanied by undesirable results, so far as machine tool driving is concerned. The greater the resistance in the armature circuit, the greater will be the drop in speed between

no load and full load, and it is evident that on many classes of work, such, for example, work involving intermittent cuts, a tool would very quickly be ruined.

It is possible on a machine of this type, by giving the brushes back lead, to produce a certain demagnetizing armature reaction which will counteract the resistance drop in the reaction winding at normal speeds. This, however, is a dangerous procedure, for the reason that when the higher speeds are reached the field is extremely weak and there is a possibility of the field being reversed, in which case the motor will draw an abnormally heavy current, and in all probability be burned out, provided the fuses or other protective devices do not open the circuit promptly.

It is claimed by the manufacturers of this motor that a range of speed as high as 1 to 6 on single voltage is entirely possible, the horsepower remaining constant throughout the whole speed range. While it is not the intention to go into the matter of the practical speed range on an electric motor for machine tool driving, it is sufficient to say, however, that the size and weight of a variable speed motor of given output, operating on any system, whether it be multi-voltage or field control, will increase as the minimum speed of the motor decreases. When a range of speed of 1 to 6 is obtained the minimum speed must be kept fairly low for mechanical reasons, and there is some question as to whether speed range of 1 to 6 on a single voltage represents the best practice.

A properly designed shunt or compound wound motor may for machine tool service be operated throughout a speed range of 1 to 2 on a single voltage by field control without the use of reaction windings, or in fact any device especially intended to minimize the sparking at the commutator. This system presents the simplest variable speed mechanism yet developed for moderate speed ranges. The motor is a standard motor; the number of wires is reduced to a minimum and the speed range is sufficient to eliminate a considerable amount of intermediate gearing, the coarser increments being obtained by gears, frequently in combination with clutches, or belts and cone pulleys. With this range of speed, at a given output, a motor of normal size may be employed with a corresponding decrease in the cost as compared with the wider speed ranges, and the generating outfit presents the simplest possible solution for a power and lighting distribution plant.

Some of the machine tool builders of to-day have adopted a speed range of 1 to 2 as the standard, claiming thereby that they can produce motor driven machines cheaper, using a 1 to 2 motor with the decreased amount of gearing, than would be possible were a constant speed motor used, and that the machine tool may be produced cheaper than would be the case were a greater range obtained electrically with a decreased amount of gearing.

This system has been consistently advocated by one of the large manufacturing companies, and there are to-day many installations in which motors having a speed range of 1 to 2 on a single voltage are operating with

entire satisfaction. The horsepower output is constant throughout the whole speed range and the commutation is all that could be desired. The controller has but one armature voltage to handle, while the field current is comparatively small and may be handled without difficulty.

A natural extension of this system leads to the 3-wire, 2-voltage system, using equal voltages on either side of the neutral wire and eliminating the rotating balancing set. The rotating balancing set, while a comparatively small machine, cannot be particularly efficient, and operating as it does all day, its losses in the course of a year represent an appreciable amount. Its elimination, aside from the complication which it introduces into a system is, therefore, desirable on the ground of economy. On the 3-wire system, 120 and 240 volts are available at the motors, and, because of the fact that the speed of the motor varies approximately as the voltage applied to its terminals, it is evident that on the 120 volts a speed range of 1 to 2 by field control may be obtained; that after the motor has reached the highest speed on 120 volts, its armature may be thrown on 240 volts, and a further speed range of 1 to 2 may be obtained, giving a total range of 1 to 4. The system of distribution used in the Edison Three-Wire system, which involves a minimum amount of copper for the transmission of a given horsepower, and the controller handles but two voltages in addition to the field current. By decreasing the minimum speed, with the consequent increase in the size of the motor, a greater speed range than 1 to 4 may be obtained; it is questionable, however, whether a greater speed range is economical for any class of machine tool work. Under the ratings given by the Westinghouse Electric & Manufacturing Company the horsepower which may be obtained from a motor operated on the 3-wire 2-voltage system is constant throughout the whole speed range. The application of motors operated on the 3-wire system to the driving of all classes of machine tools requiring variable speed gives increments in speed between the successive steps of the controller of about 12 per cent, which is considered fine enough for even the most modern practice involving the use of high speed steels and machine tools adapted to their use.

For group driving, so-called, constant speed motors may be operated from the 240 volt circuit obtainable when a 3-wire generator is used, but it should be noted in this connection that these motors are capable of a certain amount of speed variation by means of rheostats placed in their fields; for example, on certain sizes as much as 50 per cent variation in speed may be obtained; that is, the line shaft may be speeded up 50 per cent merely by the insertion of a rheostat in the field of the driving motor. With the rapid change in manufacturing conditions, such as the introduction of high speed steels, it is frequently a matter of prime importance that the speed of the line shaft may be increased by small increments from time to time, thereby speeding up the driven machinery. This method has been used to advantage, and the production has been known to increase in spite

of the opposition of the various machine tool operators.

This system adapts itself well to illuminating purposes, the lights, standard 110-120 volt lamps, being operated between the neutral and either outside wire of the 3-wire circuit. By the use of the 3-wire circuit it is possible to so balance the motors on either side of the neutral when running on the lower voltage, that the quantity of current flowing through the neutral wire will be a minimum; if the motors were so distributed as to draw exactly the same amount of current from either side of the 3-wire system, the neutral wire would carry no current whatever. This condition is, of course, ideal, but can be approximated very much more closely with the 3-wire balanced system than is possible with any of the so-called multi-voltage systems.

#### ELECTRICAL DISTRIBUTION AT ANGUS.

There are three alternating-current and one direct-current circuits from the power house entering the machine shop. Each circuit comes to a large distributing board, from which circuits are distributed in the shop. Each of these circuits serve approximately 100 h. p. of motor capacity. The leads are taken from the distributing board, which is located in the gallery, above and outside the machine gallery, by three heavy insulated wires, carried on porcelain insulators along the roof trusses. The motor connections are made directly to these leads at the most convenient point. On each lead, just before the motor connection is taken off, is located an oil circuit breaker in a convenient position. There are no fuses, switches or other instruments in this circuit up to this breaker. The leads to the motors are carried through piping down the posts or walk to the starting box of the motor. This starting box is arranged in the form of a street railway controller, and each notch cuts out resistance as the motor gains in speed. There is a no-voltage release at each oil circuit breaker.

The direct current machines, of which there are comparatively few, are taken from a circuit running the full length of the building, at the nearest available point. They have variable speed controllers and circuit breakers located on each machine. All crane motors are connected to this circuit.

The lighting circuits are taken from the three-phase line through transformers to the lighting points. The transformers are arranged in pairs, one being connected to wires 1 and 2, and the other to wires 2 and 3. These transformers change the voltage from 550 volts to 110 volts. The light distributing boards, or panels, contain two copper buss bars, from which the several lighting circuits are carried through fuses and switches. Each of these small circuits carries not more than one enclosed arc or 12 incandescent lights. There are 15 transformers in the locomotive shop and 29 lighting panels. The lighting in the erecting shop is mostly by arcs hung from the roof trusses and with incandescents along the side walls, while that in the machine shop is practically by incandescent lights. There are plug receptacles located at short distances in all pits and along the posts, as

well as at benches and any other place where they may possibly be needed.

#### NUMBER OF MACHINE TOOLS.

The peculiar local governing conditions affecting the operation of each shop, together with the fact that most shops do a certain amount of manufacturing work not only for the immediate plant, but also for various plants along the line, render it almost impossible to present a list of tools which will provide for any given or individual shop chosen at random. Consideration must be given to the kind and class of repairs necessary owing to the peculiar conditions of the road, or the section of the road, on which the locomotives to be maintained are operated. Other conditions necessarily provided for are special defects in design, such as weak frames, cylinders and other special parts.

Another consideration is the amount of manufactured material carried in stock. It is believed that some roads are inclined to force the amount of material in stock, especially manufactured material, to too low a point.

An important factor in determining the number of machine tools in the locomotive shop is the question of standard and special machinery. Where parts of locomotives are well standardized, more special machinery may be utilized, which will increase the output of the shop.

An opinion prevails that present locomotive shops would be capable of a greater output and hold locomotives out of service for a shorter period of time during repairs, if the number of machine tools per locomotive pit was increased. For this reason from 8 to 10 machines per pit have been advocated. However, the ratio of from 6 to 8 machine tools per pit is more nearly representative of the equipment in existing shops most liberally provided and many shops are operated with 5 or 6 machines per pit.

It should be explained that the following tables are acknowledged to indicate ratios of machine tools per pit more liberal than actually to be found in most existing shops. The various conditions effecting locomotive repairs in different localities necessarily influence the proportions of the several types of tools. It is, therefore, impossible to produce a table from which a list of tools could be selected without modification to suit local conditions. In placing a new shop in operation it is customary to install but a portion of the machine tool equipment planned for and to add to the equipment as the shop becomes organized. In most instances the final requirements have surpassed the original plans.

Percentage of total number of machine tools for each of the various types:

Turning tools .....	50
Cutting tools .....	25
Drilling tools .....	11
Grinding tools .....	7
Miscellaneous tools .....	7
<b>Total .....</b>	<b>100</b>

#### Number of machine tools of each class per pit:

Lathes .....	3 11-12 .....	3.925
Boring Mills .....	$\frac{7}{8}$ .....	.875
Planers .....	1 .....	1.00
Shapers .....	$\frac{1}{2}$ .....	.5
Slotters .....	11-24 .....	.458
Millers .....	$\frac{3}{8}$ .....	.375
Drills .....	1 1-12 .....	1.083
Grinders .....	2-3 .....	.666
Miscellaneous .....	17-24 .....	.708

**Total .....** 9.590

The conditions surrounding boiler work are such that it is even more impracticable to select a list of machine tools which will meet the requirements of any given boiler shop, than prevails in connection with the general machine tool equipment. There are many of the larger machines which are required singly by a locomotive shop maintaining general boiler repairs and the numbers of such machines per so many pits vary according to wide limits only.

For this reason the following list of the principal machine tools for the boiler shop has been selected, based on the requirements of a shop containing 24 or 30 erecting pits, and it is understood that the smaller or special tools should be added according to requirements of local conditions:

List of principal machine tools for boiler shop serving 24 or 30 locomotive erecting pits:

- Rotary splitting shear.
- No. 10 milling machine.
- 36-inch vertical drill.
- Staybolt drill.
- Staybolt cutter.
- 72-inch radial drill.
- Hydraulic accumulator.
- Hydraulic riveter.
- Flange fire.
- 120-inch flange clamp.
- Single punch,  $\frac{3}{4}$ -inch plate and 36-inch throat.
- Multiple punch.
- 120-inch flange clamp.
- Sectional hydraulic flange press.
- Annealing furnace.
- Flange punch.
- Plate bending roller. (Large, 16 ft. long.)
- Plate bending roller. (Small.)
- 72-inch punch—72-inch shears.
- Plate planer.
- Multiple drill.
- Cold saw.
- Angle shears.
- Punch—1½-inch holes, 1-inch plate.
- Total, 24 tools.**

*Machine Tool Equipment for the Locomotive Shop***MACHINE TOOLS FOR 1, 12, 15, 24, 48 ERECTING SHOP PITS.**

	Machines for 1 pit	Machines for 12 pits	Machines for 15 pits	Machines for 24 pits	Machines for 48 pits
Lathes .....	3.925	47	60	94	188
Boring Mills. .	.875	10	14	21	42
Planers .....	1.00	12	15	24	48
Shapers ....	.5	6	8	13	24
Slotters .....	.453	6	7	11	22
Millers .....	.375	5	6	9	18
Drills .....	1.083	13	16	26	52
Grinders ....	.666	8	9	16	32
Miscellaneous .	.708	9	10	17	34
	9.590	116	145	230	460

**MACHINE TOOLS FOR 15 ERECTING PITS.****LATHES.**

90-inch wheel lathe for turning tires .....	1
100-wheel lathe for turning tires .....	1
Quartering machine, 34-inch throw .....	1
42-inch lathes .....	2
36-inch lathes .....	4
30-inch lathes .....	5
24-inch lathes .....	6
20-inch lathes .....	7
18-inch lathes .....	12
16-inch lathes .....	12
2-inch by 24-inch turret lathes .....	2
2½-inch by 24-inch turret lathe .....	1
4¾-inch by 24-inch turret lathes.....	2
6-inch turret lathe .....	1
Special bolt turning machine .....	1
Cylinder lathe .....	1
Double axle lathe .....	1
Total .....	60

**BORING MILLS.**

96-inch boring mill .....	1
84-inch boring mill .....	3
72-inch boring mill .....	1
62-inch boring mill .....	1
51-inch boring mills .....	3
42-inch boring mills .....	2
Double rod boring machine .....	1
3-spindle cylinder borer .....	1
60-inch horizontal boring mills .....	2
36-inch boring mill turret .....	1
Total .....	14

**PLANERS.**

72-inch by 84-inch by 12-foot cylinder planer .....	1
72-inch by 72-inch by 36-foot frame planer .....	1
60-inch by 60-inch by 18-foot planer .....	1
48-inch by 48-inch by 10-foot planers .....	4
36-inch by 36-inch by 10-foot planers .....	6
30-inch by 30-inch by 8-foot planers .....	2
Total .....	15

**SHAPERS.**

18-inch double head shapers .....	3
16-inch stroke shapers .....	3
14-inch stroke shapers .....	2
Total ....	8

**SLOTTERS.**

Double head frame slotter .....	1
18-inch slotters .....	2
16-inch slotter .....	1
14-inch slotters .....	2
12-inch slotter .....	1
Total .....	7

**MILLERS.**

Vertical millers .....	2
Universal miller .....	1
Universal milling machine—tool room .....	1
Horizontal miller—tool room .....	1
Heavy horizontal miller .....	1
Total .....	6

**DRILLS.**

72-inch Universal radial drill .....	1
72-inch radial .....	1
3-spindle frame drill .....	1
60-inch radial drill presses .....	5
36-inch vertical drills .....	3
24-inch vertical drills.....	2
Drill centering machine .....	1
Total .....	14

**GRINDERS.**

Universal grinder .....	1
72-inch guide bar grinder .....	1
Universal tool grinder .....	1
Drill grinders .....	2
Piston rod grinder .....	1
Horizontal grinders .....	4
Total .....	10

**MISCELLANEOUS.**

400-ton wheel press .....	1
Pipe cutters .....	2
3½-inch single head bolt cutter.....	1
2-inch double head bolt cutter .....	1
1½-inch double head bolt cutter .....	1
Tool dresser furnace .....	1
Tool dresser trip hammer .....	1
Press for driving boxes and rod bearings .....	1
Universal cold saw .....	1
Grind stones .....	2
Total .....	12

**MACHINE TOOLS FOR 24 ERECTING PITS.****LATHES.**

Quartering machine, 34-inch throw.....	1
90-inch wheel lathe for turning tires.....	1
100-inch wheel lathe for turning tires.....	1
42 inch lathes.....	2
36 inch lathes.....	6
30 inch lathes .....	3
24 inch lathes.....	10
20 inch lathes.....	12
18 inch lathes.....	20
16 inch lathes.....	20
2 inch x 24 inch turret lathes.....	2
2½ inch x 24 inch turret lathes.....	2
4¾ inch x 24 inch turret lathes.....	3
6 inch turret lathe.....	1
Speci bolt turning machine .....	1

## RAILWAY SHOP UP TO DATE

Cylinder lathes .....	2
Double axle lathes .....	2
—	
94	
<b>BORING MILLS.</b>	
96-inch boring mill .....	1
84-inch boring mill .....	1
72-inch boring mills .....	2
51-inch boring mills .....	6
42-inch boring mills .....	4
Double rod boring machine .....	1
Cylinder borer .....	1
3 spindle cylinder borer .....	1
60-inch horizontal boring mills.....	2
36-inch boring mills, turret .....	2
—	
21	
<b>PLANERS.</b>	
72-inch by 84-inch by 12-foot cylinder planer.....	1
72-inch by 72-inch by 36-foot frame planer .....	1
60-inch by 60-inch by 18-foot planers .....	2
48-inch by 48-inch by 10-foot planers .....	6
36-inch by 36-inch by 10-foot planers .....	10
30-inch by 30-inch by 8-foot planer .....	4
—	
24	
<b>SHAPERS.</b>	
18-inch double head shapers .....	4
16-inch stroke shapers .....	6
14-inch stroke shapers .....	2
—	
12	
<b>SLOTTERS.</b>	
Double head frame slotter .....	1
18-inch slotters .....	2
16-inch slotters .....	2
14-inch slotters .....	4
12-inch slotters .....	2
—	
11	
<b>MILLERS.</b>	
Vertical millers .....	2
Universal millers .....	2
Universal milling machine, tool room .....	1
Horizontal millers .....	2
Heavy horizontal and vertical .....	2
—	
9	
72-inch Universal radial drills .....	2
72-inch radial drill .....	1
3 spindle frame drill .....	1
60-inch radial drill presses .....	8
36-inch vertical drills .....	6
24-inch vertical drills .....	3
High speed drills .....	3
Drill centering machines .....	2
—	
26	
<b>GRINDERS.</b>	
Universal grinders .....	2
72-inch guide bar grinders .....	2
Universal tool grinders .....	2
Drill grinders .....	2
Piston rod grinders .....	2
Horizontal grinders .....	6
—	
16	
<b>MISCELLANEOUS.</b>	
400-ton wheel press .....	1
Pipe cutters .....	3
2½-inch double head bolt cutters .....	2
2-inch bolt cutters .....	2
1½-inch bolt cutters .....	2
Tool dresser furnace .....	1
Tool dresser trip hammer .....	1
Presses for driving boxes and rod bearings .....	2
Universal cold saw .....	1
Grind stones .....	2
—	
17	

*Classified List of Machine Tools for 1, 1<sub>2</sub>, 15, 24 and 48 Erecting Shop Pit*

	100 in.	90 in.	42 in.	36 in.	30 in.	24 in.	20 in.	18 in.	16 in.	2x24 in.
Per Pit .....	1/24	1/24	1/12	1/4	1/3	5/12	1/2	5/6	5/6	1/12
Per 12 Pits .....	1/2	1/2	1	3	4	5	6	10	10	1
Per 15 Pits .....	5/8	5/8	1 1/4	4	5	6 1/4	7 1/2	12 1/2	12 1/2	1 1/4
Per 24 Pits .....	1	1	2	6	8	10	12	20	20	2
Per 48 Pits .....	2	2	4	12	16	20	24	40	40	4

## LATHES—Continued.

	2½x24 in.	4¾x24 in.	6 in.	Special Bolt	Cyl.	Axle	Wheel Quartering	Total
Per Pit .....	1/12	1/8	1/24	1/24	1/24	1/12	1/24	3 11/12
Per 1 Pit .....	1	1 1/2	1/2	1/2	1/2	1	1/2	47
Per 12 Pits .....	1 1/4	1 7/8	5/8	5/8	5/8	1 1/4	5/8	53
Per 24 Pits .....	2	3	1	1	2	2	1	94
Per 48 Pits .....	4	6	2	2	4	4	2	188

**BORING MILLS.**

	96 in.	84 in.	72 in.	51 in.	42 in.	36 in.	D Rod Borer	Cyl. Borer	Spindle Cyl.	60 in. Hori.	Total
Per Pit .....	1/24	1/24	1/12	1/4	1/6	1/12	1/24	1/24	1/24	1/12	7/8
Per 12 Pits .....	1/2	1/2	1	3	2	1	1/2	1/2	1/2	1	10 1/2
Per 15 Pits .....	5/8	5/8	1 1/4	4	2 1/2	1 1/4	5/8	5/8	5/8	1 1/4	12
Per 24 Pits .....	1	1	2	6	4	2	1	1	1	2	21
Per 48 Pits .....	2	2	4	12	8	4	2	2	2	4	42

## PLANERS.

	72 in.	60 in.	48 in.	36 in.	30 in.	72 in.	Total
Per Pit .....	1/24	1/12	1/4	5/12	1/6	1/24	1
Per 12 Pits .....	1/2	1	3	5	2	1/2	12
Per 15 Pits .....	5/8	1 1/4	3 3/4	6 1/4	2 1/2	5/8	15
Per 24 Pits .....	1	2	6	10	4	1	24
Per 48 Pits .....	2	4	12	20	8	2	48

## SHAPERS.

	18 in.	16 in.	14 in.	Total
Per Pit .....	1/6	1/4	1/12	1/2
Per 12 Pits .....	2	3	1	6
Per 15 Pits .....	2 1/2	3 3/4	1 1/4	7 1/2
Per 24 Pits .....	4	6	2	12
Per 48 Pits .....	8	12	4	24

## SLOTTERS.

	18 in.	16 in.	14 in.	12 in.	Double head frame	Total
Per Pit .....	1/12	1/12	1/6	1/12	1/48	21/48
Per 12 Pits .....	1	1	2	1	1/4	5 1/4
Per 15 Pits .....	1 1/4	1 1/4	2 1/2	1 1/4	15/48	6 27/48
Per 24 Pits .....	2	2	4	2	1/2	11
Per 48 Pits .....	4	4	8	4	1	21

## MILLERS.

	Univ.	Vert.	Hori.	Tool room	Heavy Hori.	Total
Per Pit .....	1/12	1/12	1/12	1/24	1/12	3/8
Per 12 Pits .....	1	1	1	1/2	1	4 1/2
Per 15 Pits .....	1 1/4	1 1/4	1 1/4	5/8	1 1/4	5 5/8
Per 24 Pits .....	2	2	2	1	2	9
Per 48 Pits .....	4	4	4	2	4	18

## GRINDERS.

	72 in. Guide	Drill rod	Piston	Horizontal	Universal	Universal Tool	Total
Per Pit .....	1/12	1/12	1/12	1/4	1/12	1/12	2/3
Per 12 Pits .....	1	1	1	3	1	1	8
Per 15 Pits .....	1 1/4	1 1/4	1 1/4	3 3/4	1 1/4	1 1/4	10
Per 24 Pits .....	2	2	2	6	2	2	16
Per 48 Pits .....	4	4	4	12	4	4	32

## DRILLS.

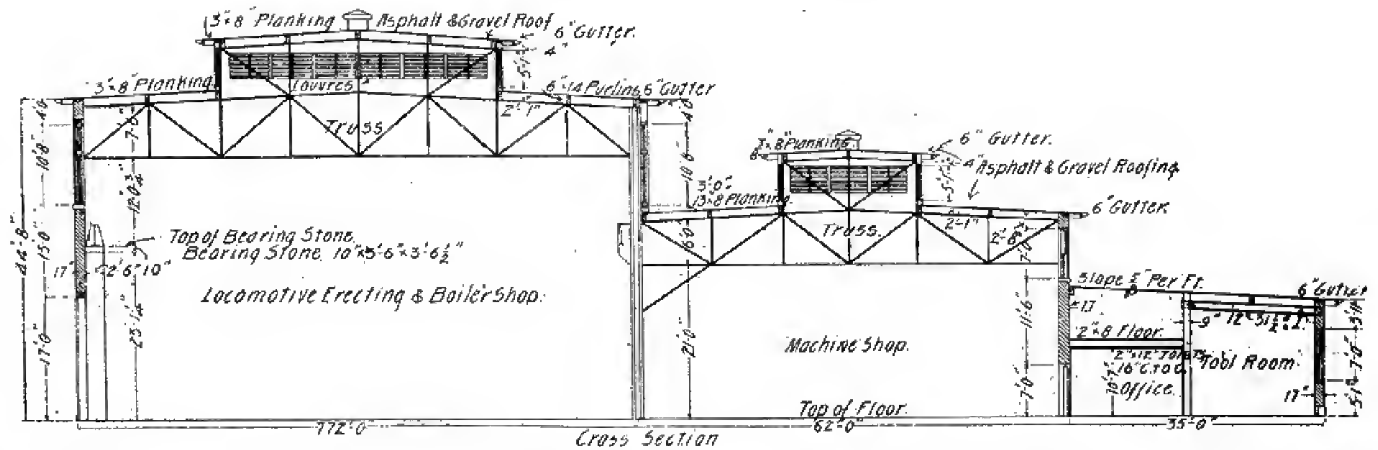
	72 in.	60 in.	36 in.	24 in.	High speed	Centering	3 spindle frame	Total
Per Pit .....	1/8	1/3	1/4	1/8	1/8	1/12	1/24	1/2
Per 12 Pits .....	1 1/2	4	3	1 1/2	1 1/2	1	1/2	1/2
Per 15 Pits .....	7/8	5	3 3/4	1 7/8	1 7/8	1 1/4	5/8	16 1/4
Per 24 Pits .....	3	8	6	3	3	2	1	26
Per 48 Pits .....	6	16	12	6	6	4	2	52

## MISCELLANEOUS.

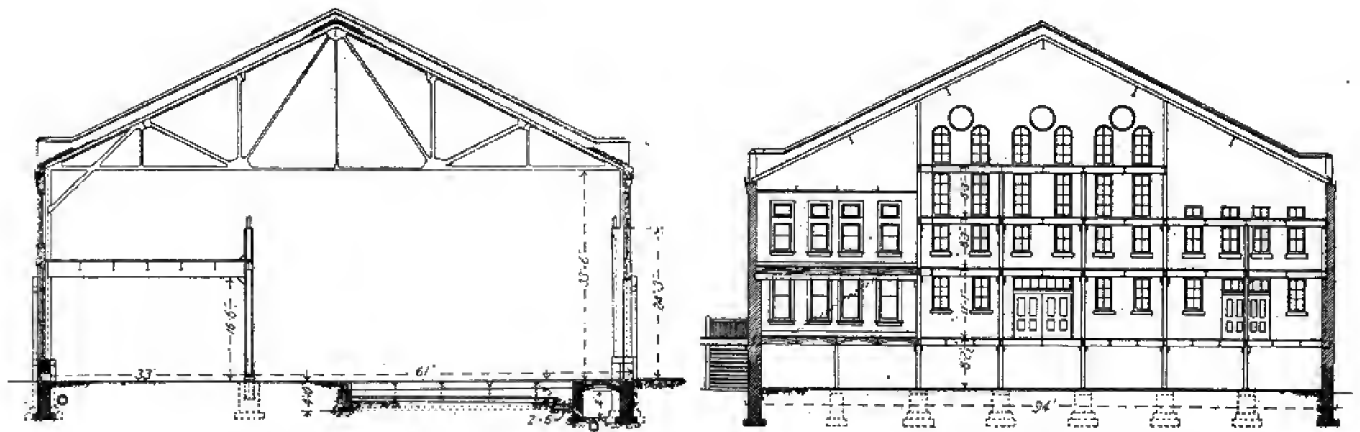
	Wheel Press	Pipe Cutter	Bolt Cutter	Tool Furnace	Trip Hammer	Press	Cold Saw	Grind Stone	Total
Per Pit .....	1/24	1/8	1/4	1/24	1/24	1/24	1/24	1/12	2/3
Per 12 Pits .....	1/2	1 1/2	3	1/2	1/2	1/2	1/2	1	8
Per 15 Pits .....	5/8	1 7/8	3 3/4	5/8	5/8	5/8	5/8	1 1/4	10
Per 24 Pits .....	1	3	6	1	1	2	1	2	17
Per 48 Pits .....	2	6	12	2	2	4	2	4	34



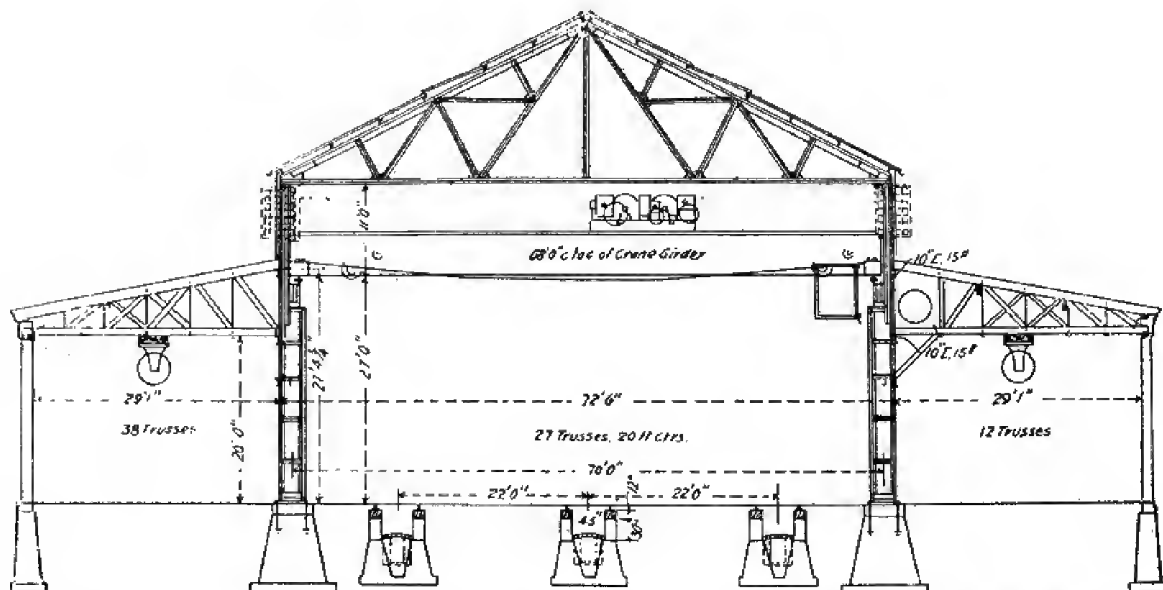
## RAILWAY SHOP UP TO DATE



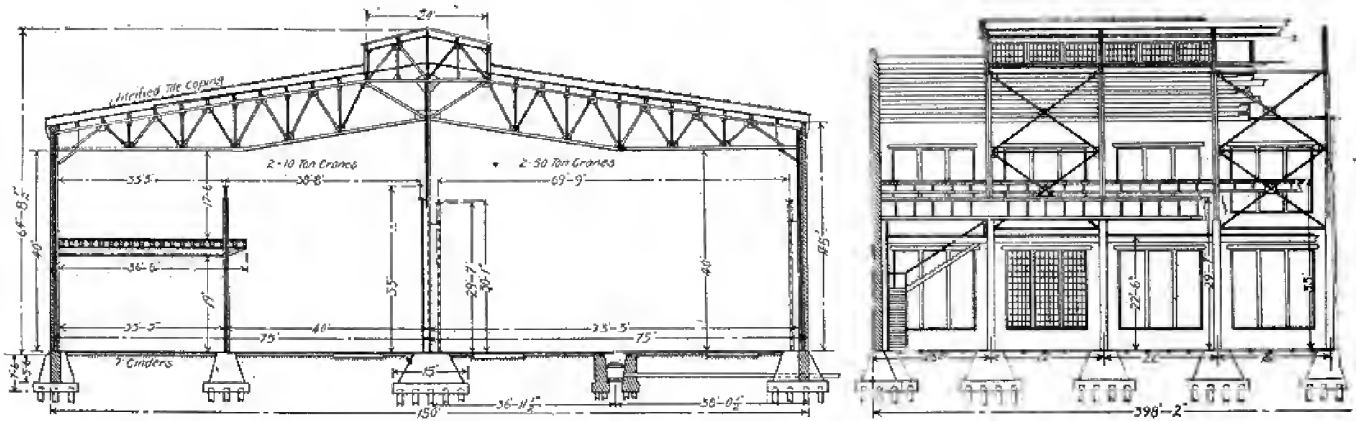
CROSS SECTION OF LOCOMOTIVE SHOP AT BARING CROSS, ARK., ST. L. I. M. & S. RY.—ERECTING FLOOR AND BOILER DEPARTMENT IN MAIN BUILDING. MACHINE DEPARTMENT IN SIDE BAY. TRANSVERSE ERECTING PITS.



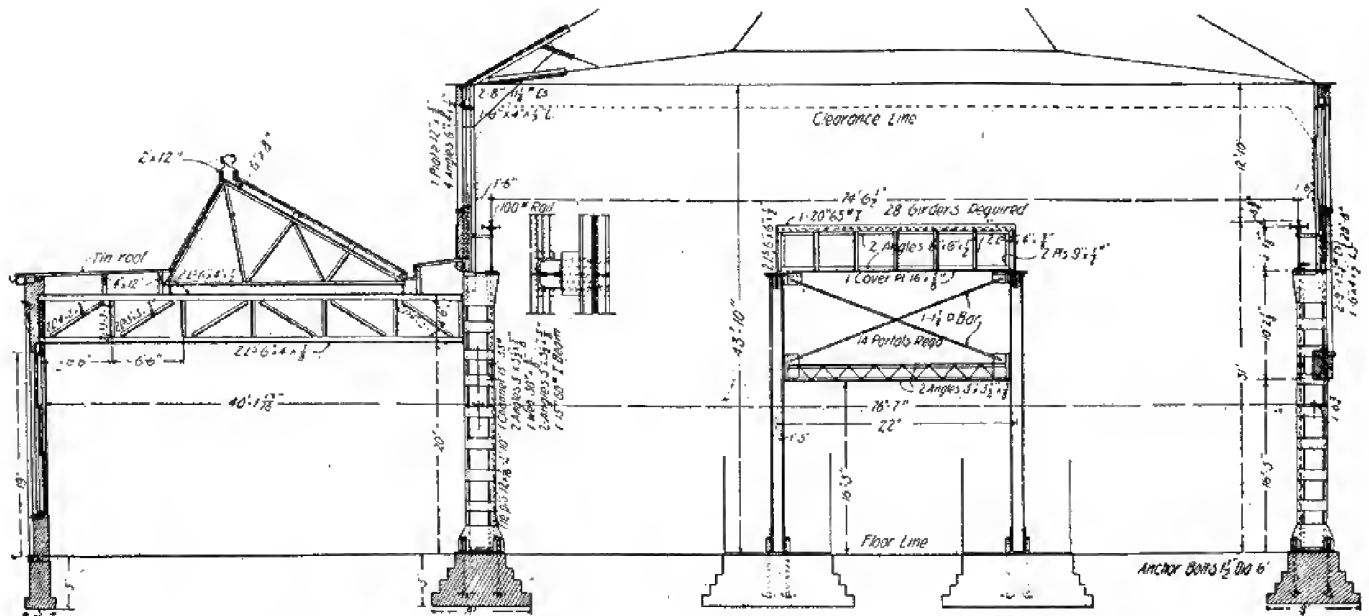
CROSS SECTION AND END ELEVATION OF LOCOMOTIVE SHOP AT OELWEIN, IA., C. G. W. RY.—ROOF TRUSS SPANS ENTIRE WIDTH OF SHOP. AUXILIARY DEPARTMENTS AND PORTION OF MACHINE TOOL EQUIPMENT IN BALCONY. TRANSVERSE ERECTING PITS.



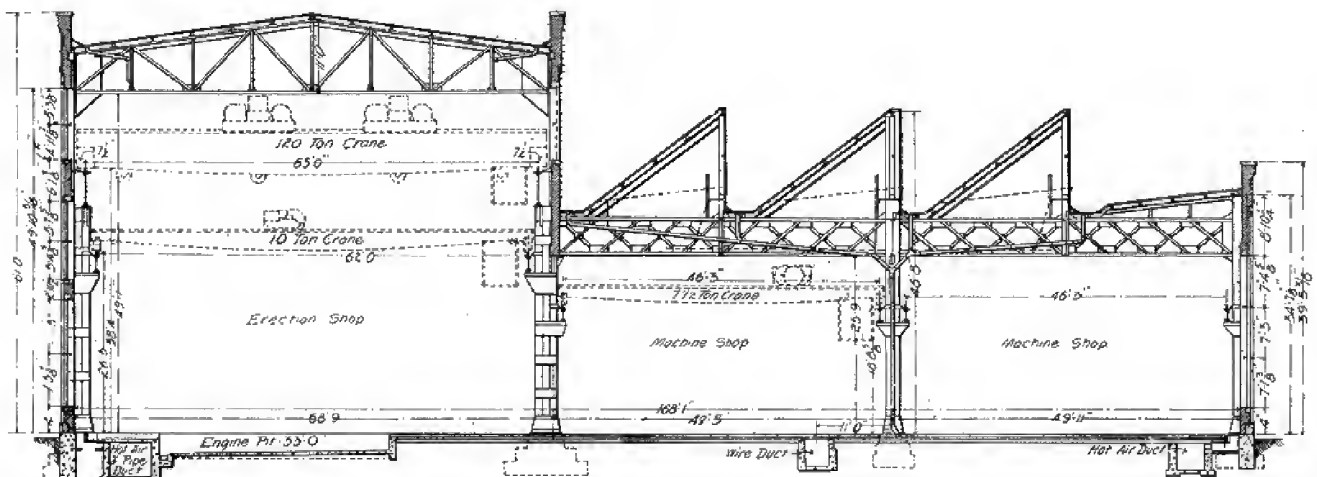
CROSS SECTION OF LOCOMOTIVE SHOP AT DU BOIS, PA., B. R. & P. RY.—ERECTING FLOOR IN CENTRAL BAY WITH MACHINE TOOL EQUIPMENT IN TWO SIDE BAYS ON OPPOSITE SIDES OF ERECTING BAY. LONGITUDINAL ERECTING



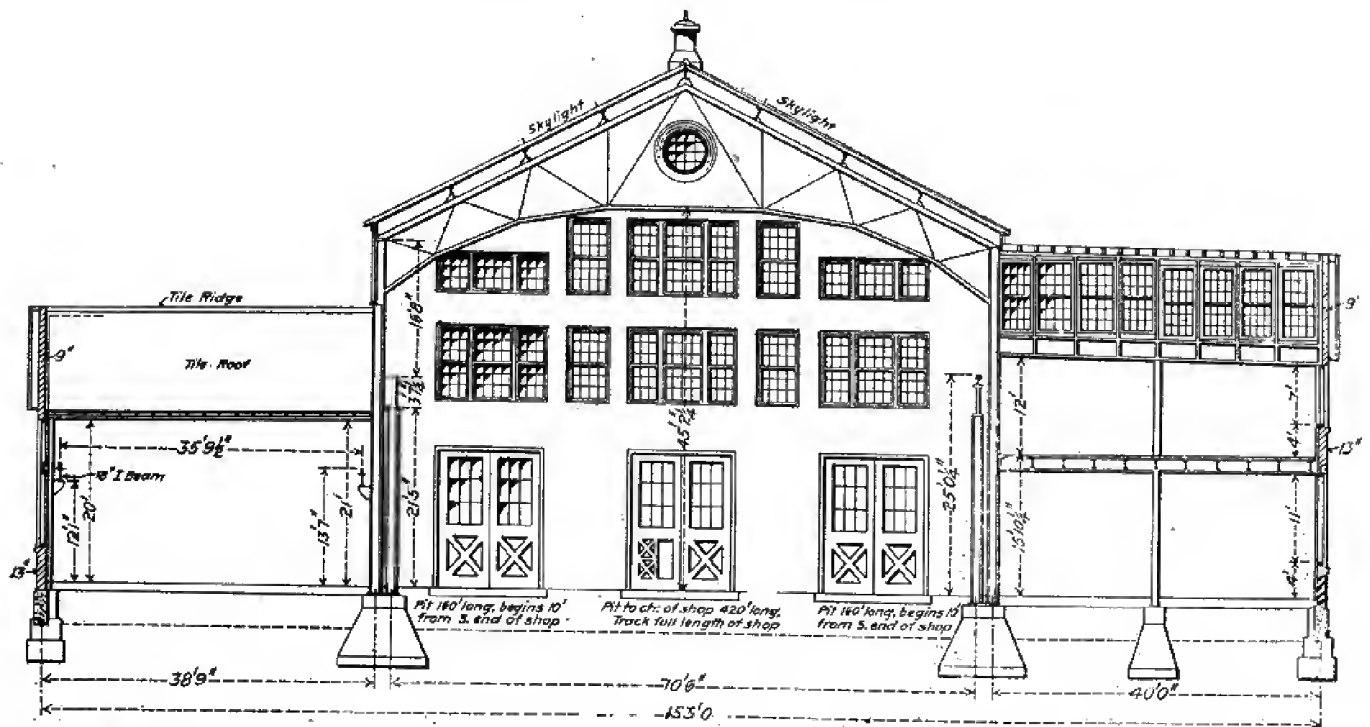
CROSS SECTION AND PARTIAL SIDE ELEVATION OF LOCOMOTIVE SHOP AT OMAHA, NEBR., U. P. R.—ERECTING FLOOR AND MACHINE TOOL DEPARTMENT IN PARALLEL BAYS OF SAME WIDTH. AUXILIARY DEPARTMENTS AND PORTION OF MACHINE TOOL EQUIPMENT IN BALCONY. LONGITUDINAL ERRECTING PITS.



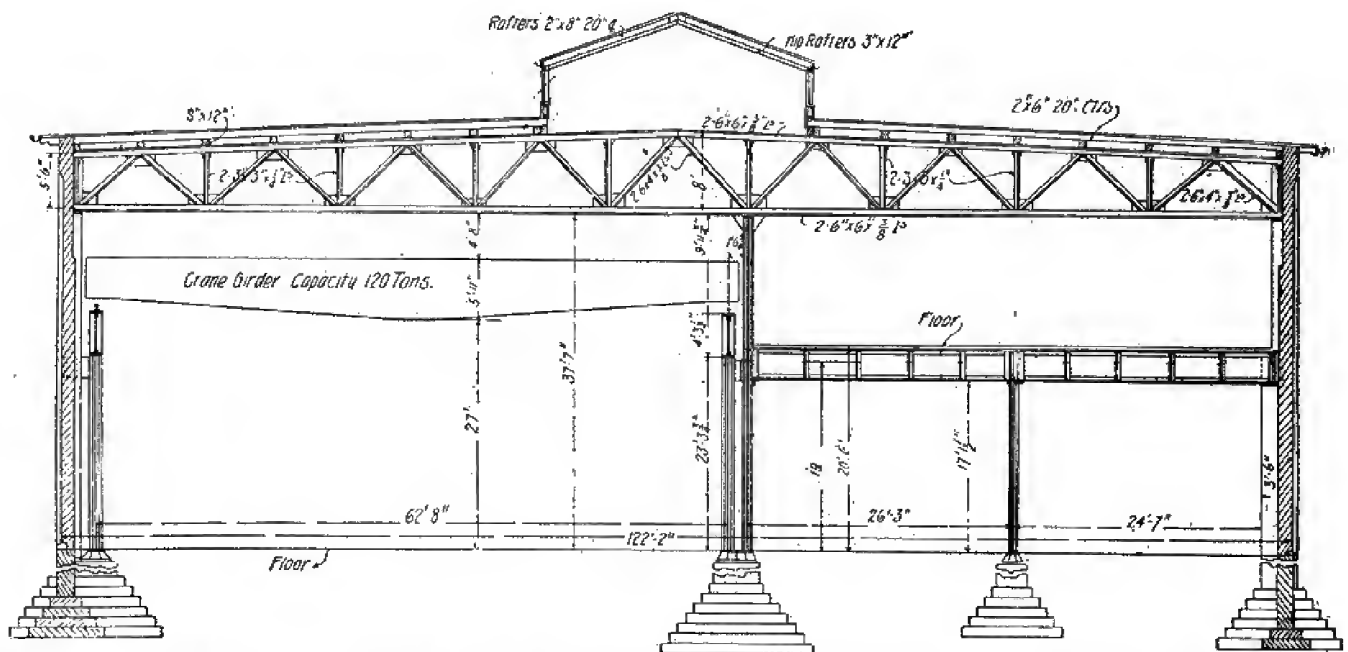
CROSS SECTION OF LOCOMOTIVE SHOP AT DANVILLE, ILL., C. & E. I. R. R.—ERECTING FLOOR IN MAIN BAY, WITH MACHINE TOOL EQUIPMENT IN SIDE BAY. HEAVY MACHINES IN MAIN BAY UNDER ERRECTING FLOOR CRANE. TRANSVERSE ERRECTING PITS.



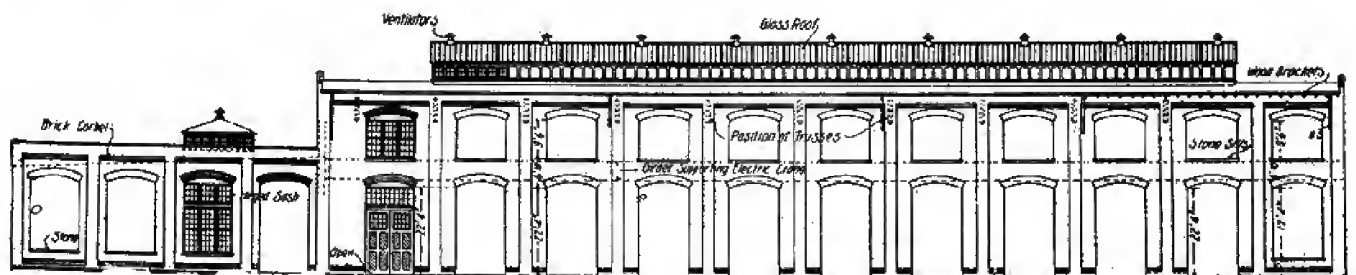
CROSS SECTION OF LOCOMOTIVE SHOP AT MCKEES ROCKS, PA., P. & L. E. R. R.—ERECTING FLOOR IN MAIN BAY WITH MACHINE TOOL EQUIPMENT IN TWO SIDE BAYS ON SAME SIDE OF ERRECTING BAY—TRANSVERSE ERRECTING PITS.



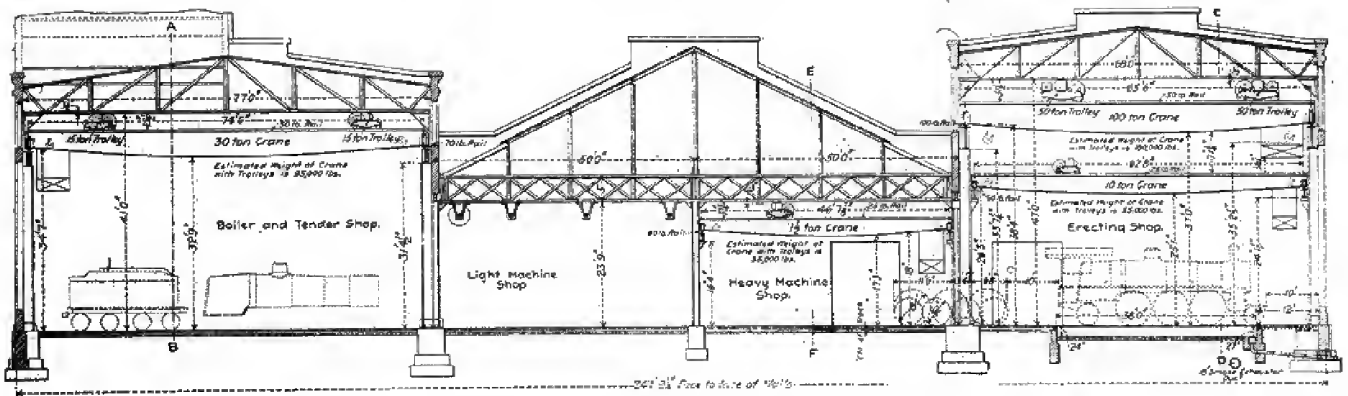
CROSS SECTION OF LOCOMOTIVE SHOP AT TOPEKA, KAN., A. T. & S. F. RY.—ERECTING FLOOR IN CENTRAL BAY WITH MACHINE TOOL EQUIPMENT IN TWO SIDE BAYS ON OPPOSITE SIDES OF ERECTING BAY. AUXILIARY DEPARTMENTS AND PORTION OF MACHINE TOOL EQUIPMENT IN BALCONY. LONGITUDINAL ERECTING PITS. BOILER DEPARTMENT CONTINUATION OF ERECTING AND MACHINE BAYS.



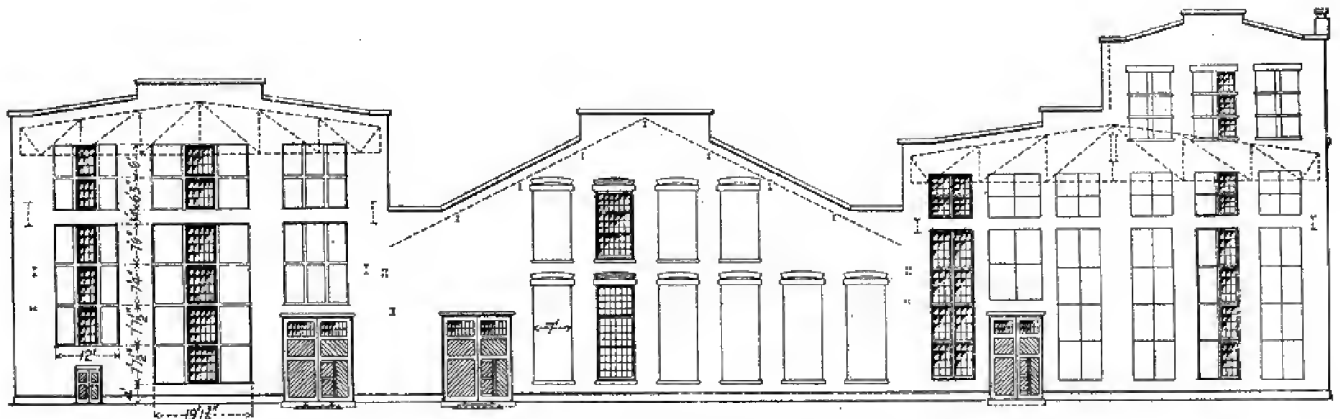
CROSS SECTION OF LOCOMOTIVE SHOP AT EAST ST. LOUIS, ILL., T. R. R. OF ST. L.—ERECTING FLOOR IN MAIN BAY WITH MACHINE TOOL EQUIPMENT IN SIDE BAY AND HEAVY MACHINES IN ONE END OF ERECTING BAY SERVED BY CRANE. TRANSVERSE ERECTING PITS.



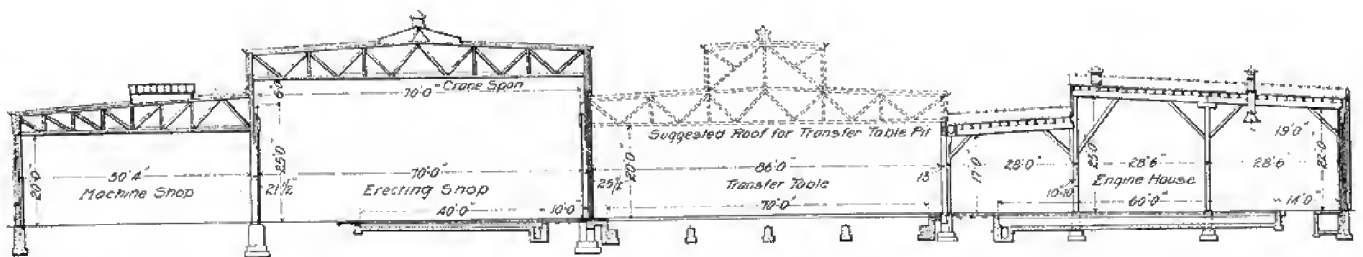
SIDE ELEVATION OF LOCOMOTIVE SHOP, WITH BLACKSMITH SHOP AT END, EAST ST. LOUIS, ILL., T. R. R. OF ST. L.



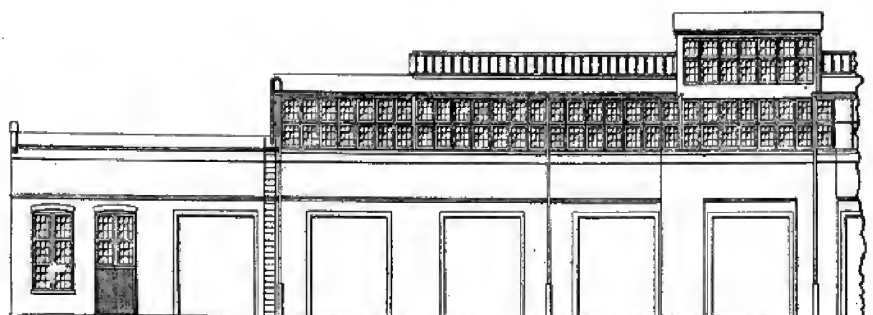
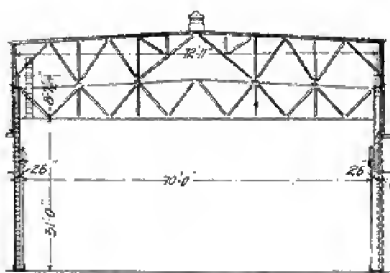
CROSS SECTION OF LOCOMOTIVE SHOP AT COLLINWOOD, O., L. S. & M. S. RY.—ERECTING AND BOILER SHOP IN OUTSIDE BAYS WITH MACHINE TOOL EQUIPMENT IN TWO INTERMEDIATE BAYS. TRANSVERSE ERECTING PITS.



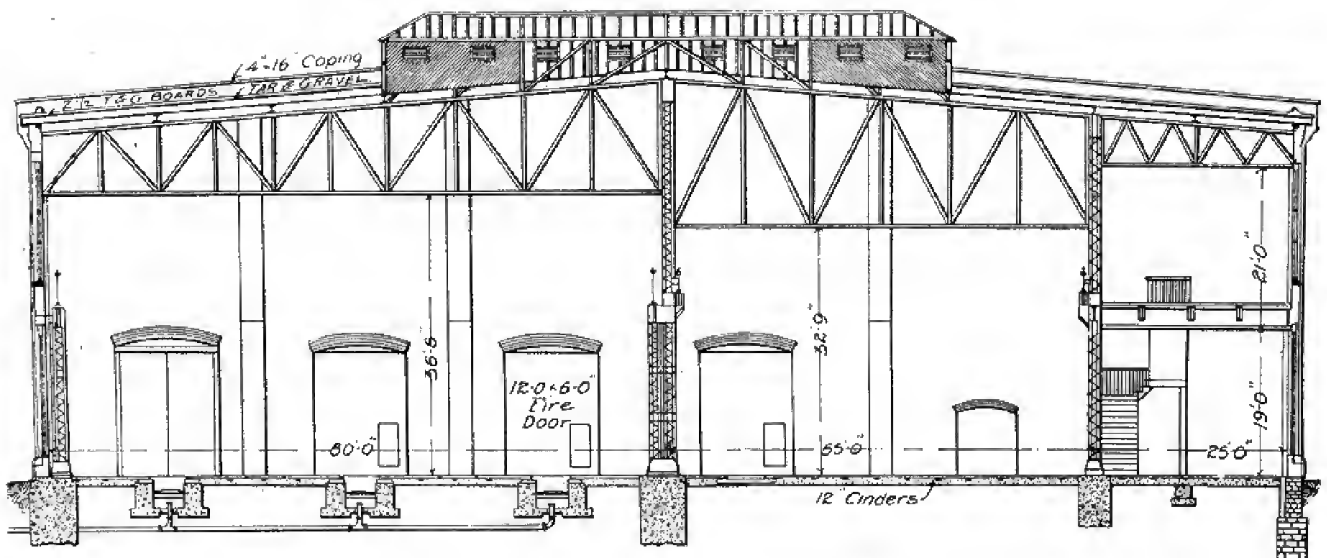
END ELEVATION OF LOCOMOTIVE SHOP AT COLLINWOOD, O., L. S. & M. S. RY.



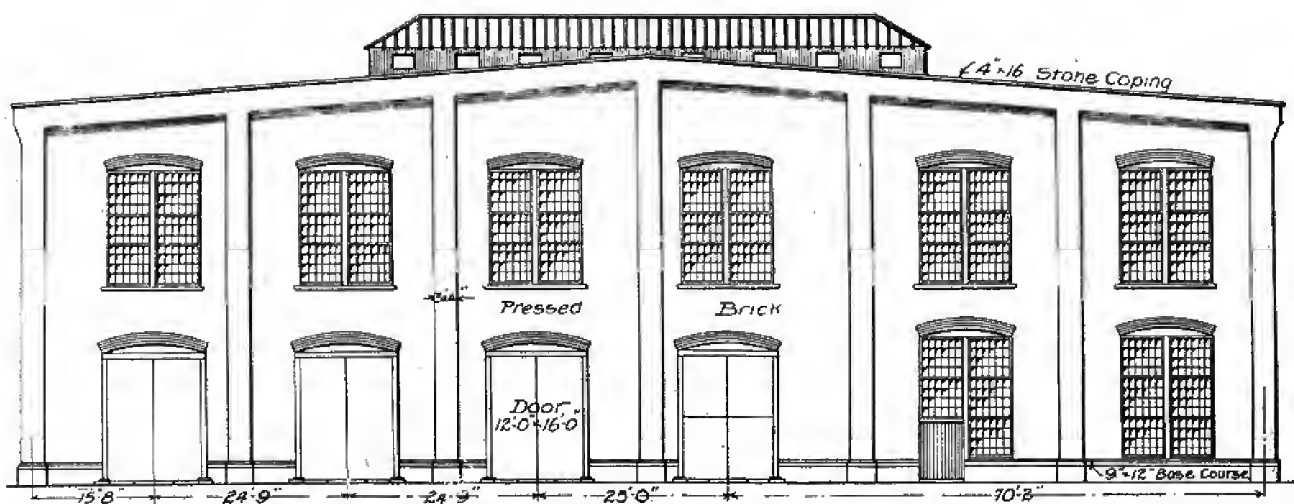
CROSS SECTION OF LOCOMOTIVE SHOP AND ENGINE HOUSE AT GRAND RAPIDS, MICH., P. M. R. R.—ERECTING SHOP AND SQUARE ENGINE HOUSE SERVED BY COMMON TRANSFER TABLE.



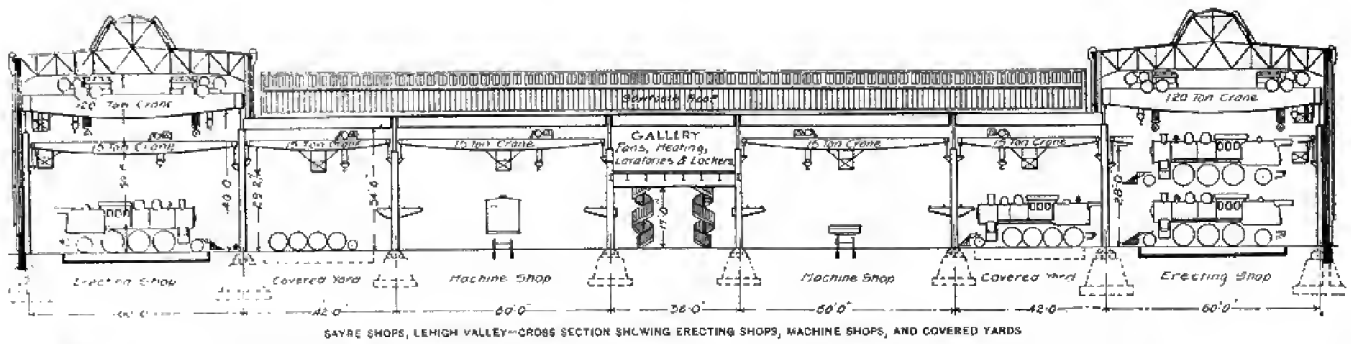
CROSS SECTION OF ERECTING BAY THROUGH PIT SERVED BY STATIONARY ELECTRIC HOIST, AND SIDE ELEVATION OF ERECTING SHOP AT GRAND RAPIDS, MICH., P. M. R. R.



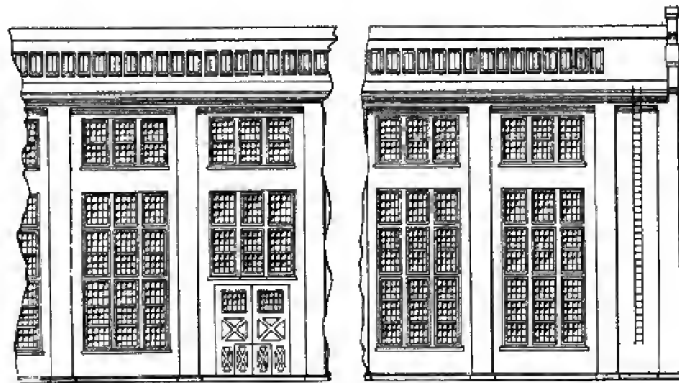
CROSS SECTION OF LOCOMOTIVE SHOP AT ANGUS (MONTREAL), C. P. RY.—ERECTING FLOOR AND MACHINE TOOL DEPARTMENT IN PARALLEL BAYS OF SAME WIDTH. AUXILIARY DEPARTMENTS AND PORTION OF MACHINE TOOL EQUIPMENT IN BALCONY. LONGITUDINAL ERECTING BAYS. BOILER DEPARTMENT CONTINUATION OF ERECTING AND MACHINE BAYS.



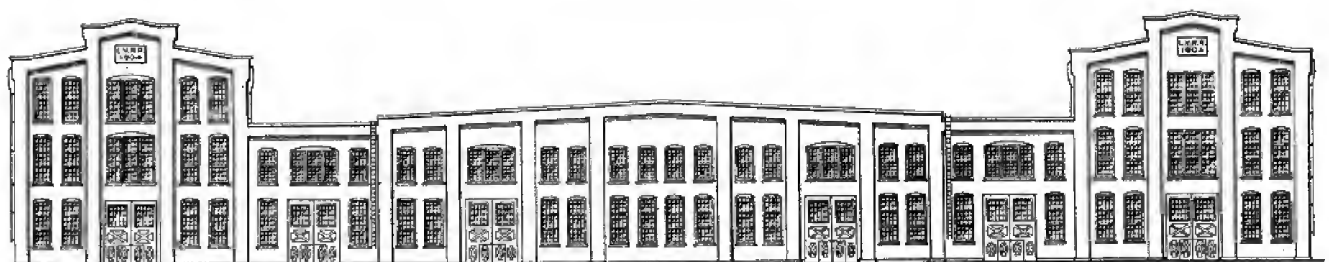
END ELEVATION OF LOCOMOTIVE SHOP AT ANGUS, C. P. RY.



CROSS SECTION OF LOCOMOTIVE SHOP AT SAYRE, PA., L. V. R. R.—ERECTING FLOORS IN TWO OUTSIDE BAYS. TWO COVERED YARDS ADJACENT TO ERECTING FLOORS. MACHINE TOOL EQUIPMENT IN TWO INTERMEDIATE BAYS AND AUXILIARY DEPARTMENTS IN CENTRAL BAY. TRANSVERSE ERECTING PITS. BOILER DEPARTMENT CONTINUATION OF ERECTING AND MACHINE BAYS.

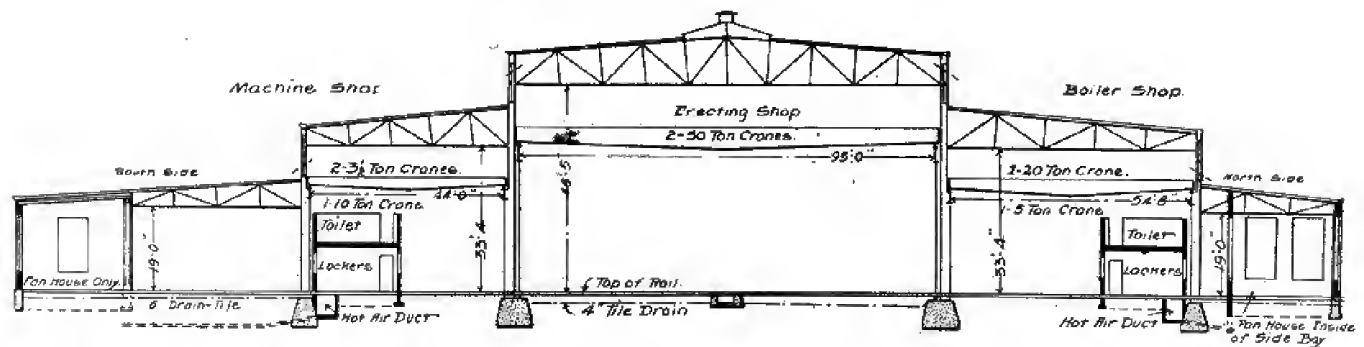


PARTIAL SIDE ELEVATION OF LOCOMOTIVE SHOP AT SAYRE, PA., L. V. R. R.

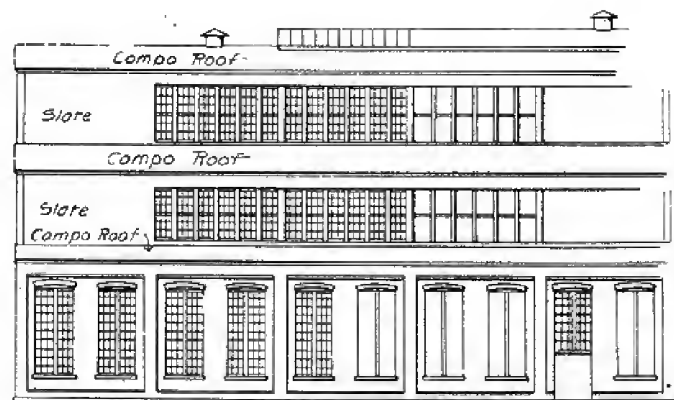


END ELEVATION OF LOCOMOTIVE SHOP AT SAYRE, PA., L. V. R. R.

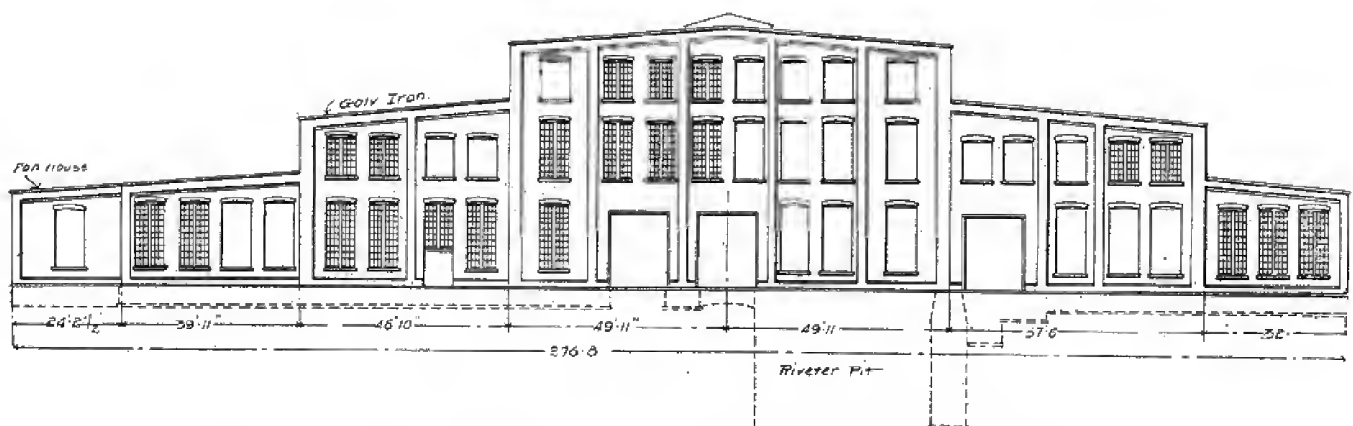
## RAILWAY SHOP UP TO DATE



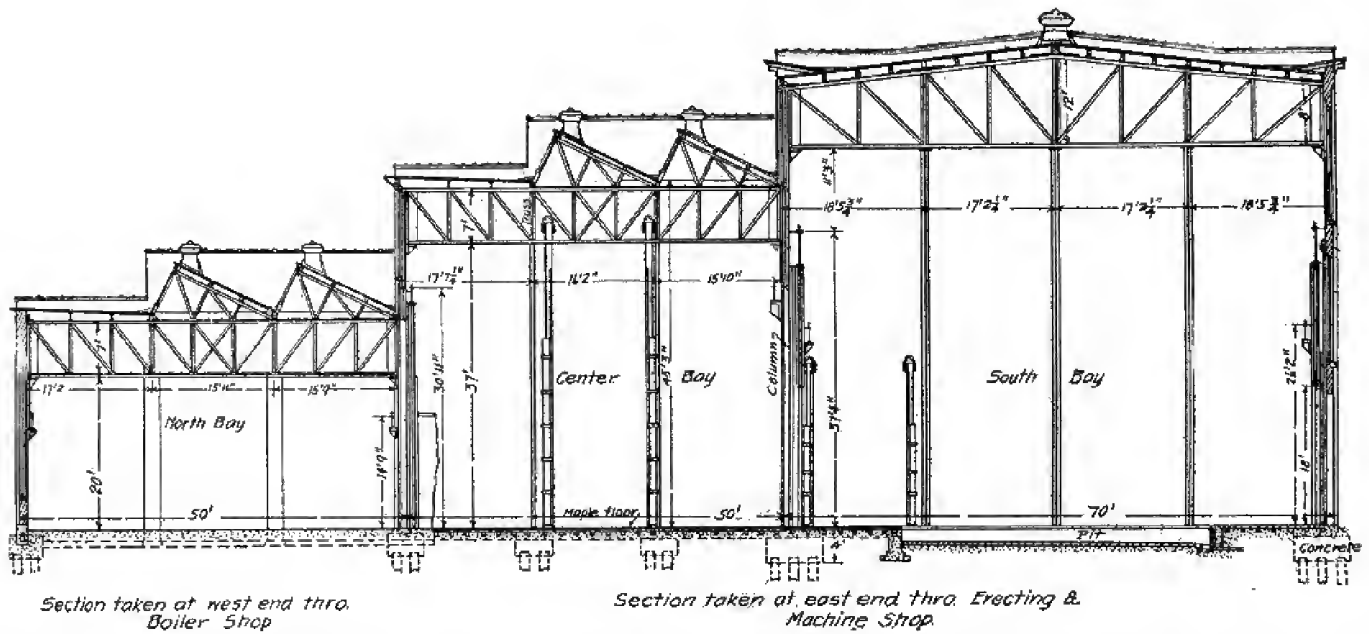
CROSS SECTION OF LOCOMOTIVE SHOP AT SILVIS, ILL., C. R. I. & P. RY.—ERECTING FLOOR IN CENTRAL BAY WITH MACHINE TOOL EQUIPMENT IN TWO SIDE BAYS ON OPPOSITE SIDES OF ERECTING BAY. DIAGONAL ERECTING PITS. BOILER DEPARTMENT CONTINUATION OF ERECTING AND MACHINE BAYS.



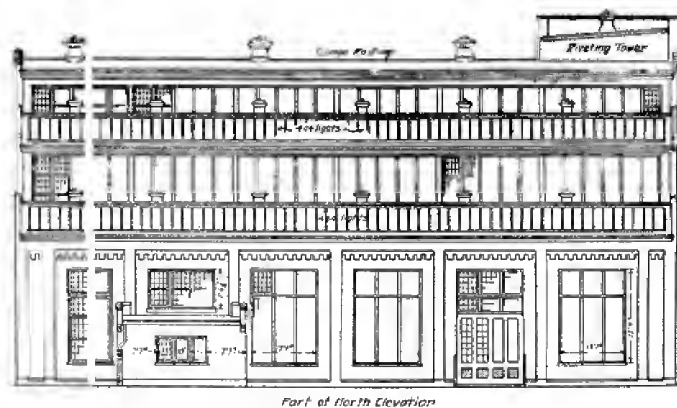
PARTIAL SIDE ELEVATION OF LOCOMOTIVE SHOP AT SILVIS, ILL., C. R. I. & P. RY.



END ELEVATION OF LOCOMOTIVE SHOP AT SILVIS, ILL., C. R. I. & P. RY.



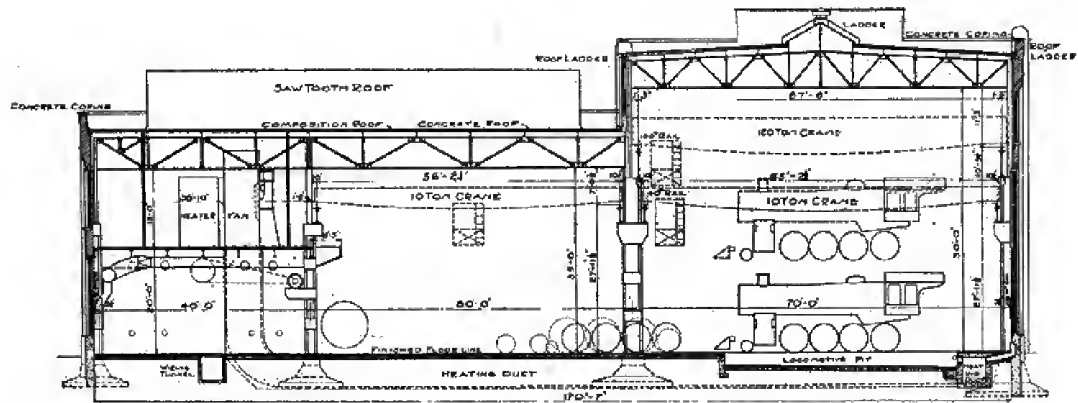
CROSS SECTION OF LOCOMOTIVE SHOP AT SOUTH LOUISVILLE, KY., L. & N. R. R.—ERECTING FLOOR IN MAIN BAY WITH MACHINE TOOL EQUIPMENT IN TWO SIDE BAYS ON SAME SIDE OF ERECTING BAY. TRANSVERSE ERECTING PITS. BOILER DEPARTMENT CONTINUATION OF ERECTING AND MACHINE BAYS.



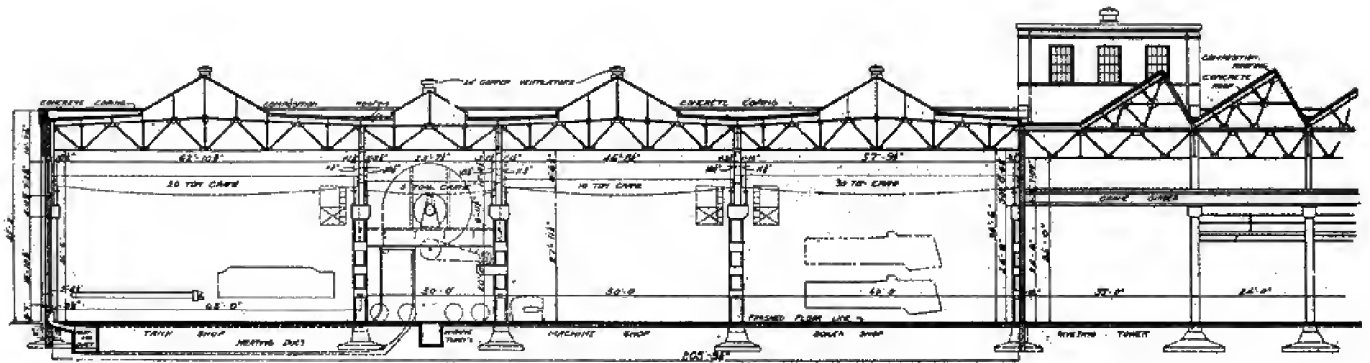
PARTIAL SIDE ELEVATION OF ERECTING SHOP AT SOUTH LOUISVILLE, KY., L. & N. R. R.



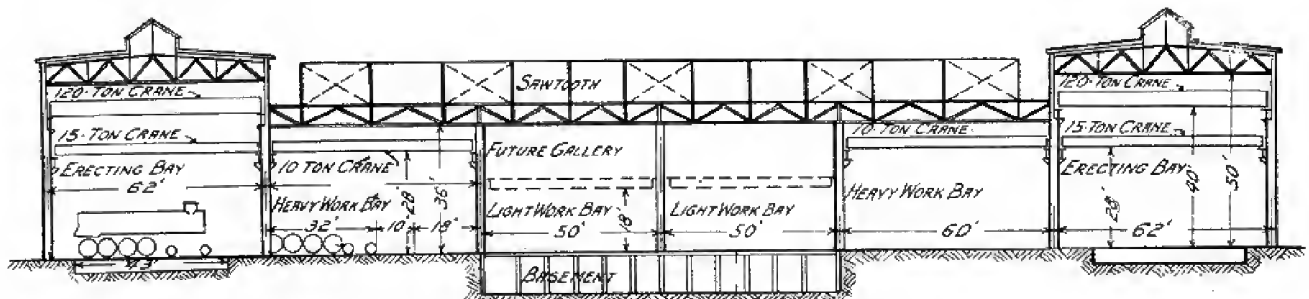
END AND PARTIAL SIDE ELEVATION OF LOCOMOTIVE SHOP AT SOUTH LOUISVILLE, KY., L. & N. R. R.



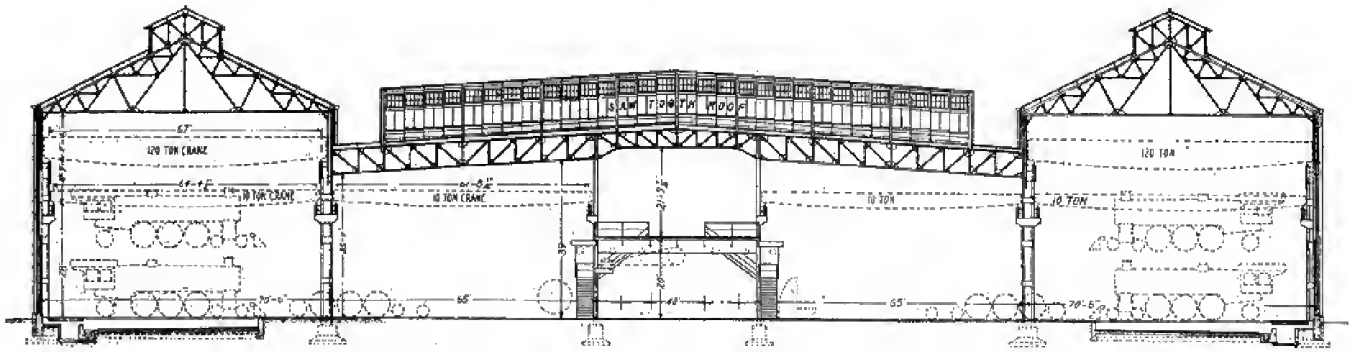
CROSS SECTION OF MACHINE AND ERECTING SHOP AT BATTLE CREEK, MICH., GRAND TRUNK RAILWAY.



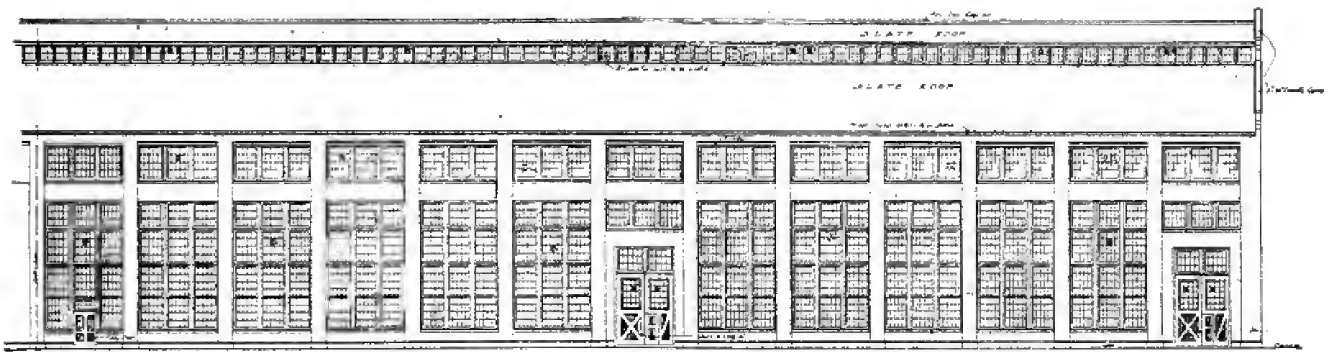
CROSS SECTION OF BOILER AND TANK SHOP AT BATTLE CREEK, MICH., GRAND TRUNK RAILWAY.



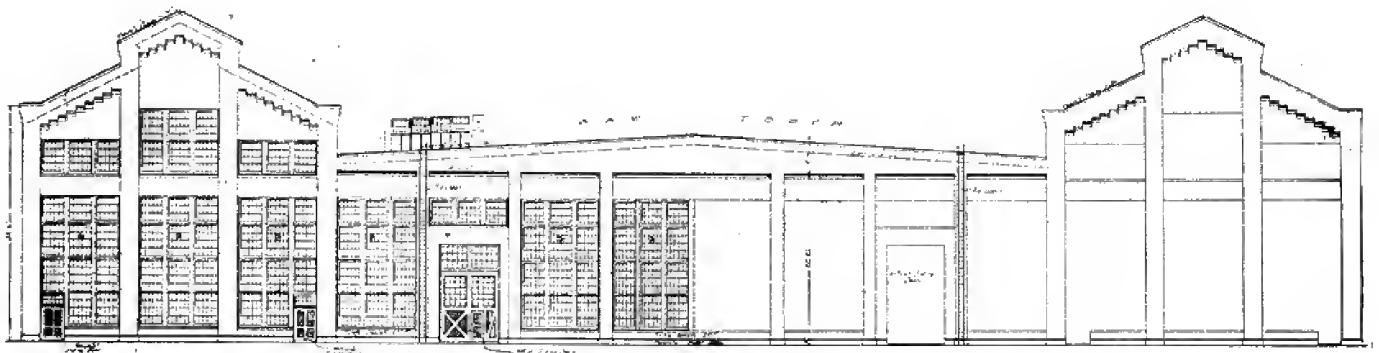
CROSS SECTION OF LOCOMOTIVE SHOP AT SCRANTON, PA., DELAWARE, LACKAWANNA & WESTERN RAILROAD.



CROSS SECTION OF LOCOMOTIVE SHOP AT BEECH GROVE (INDIANAPOLIS), IND., C. C. C. & ST. L. RY.—MODIFICATION OF LEHIGH VALLEY RY. LOCOMOTIVE SHOP AT SAYRE, PA.

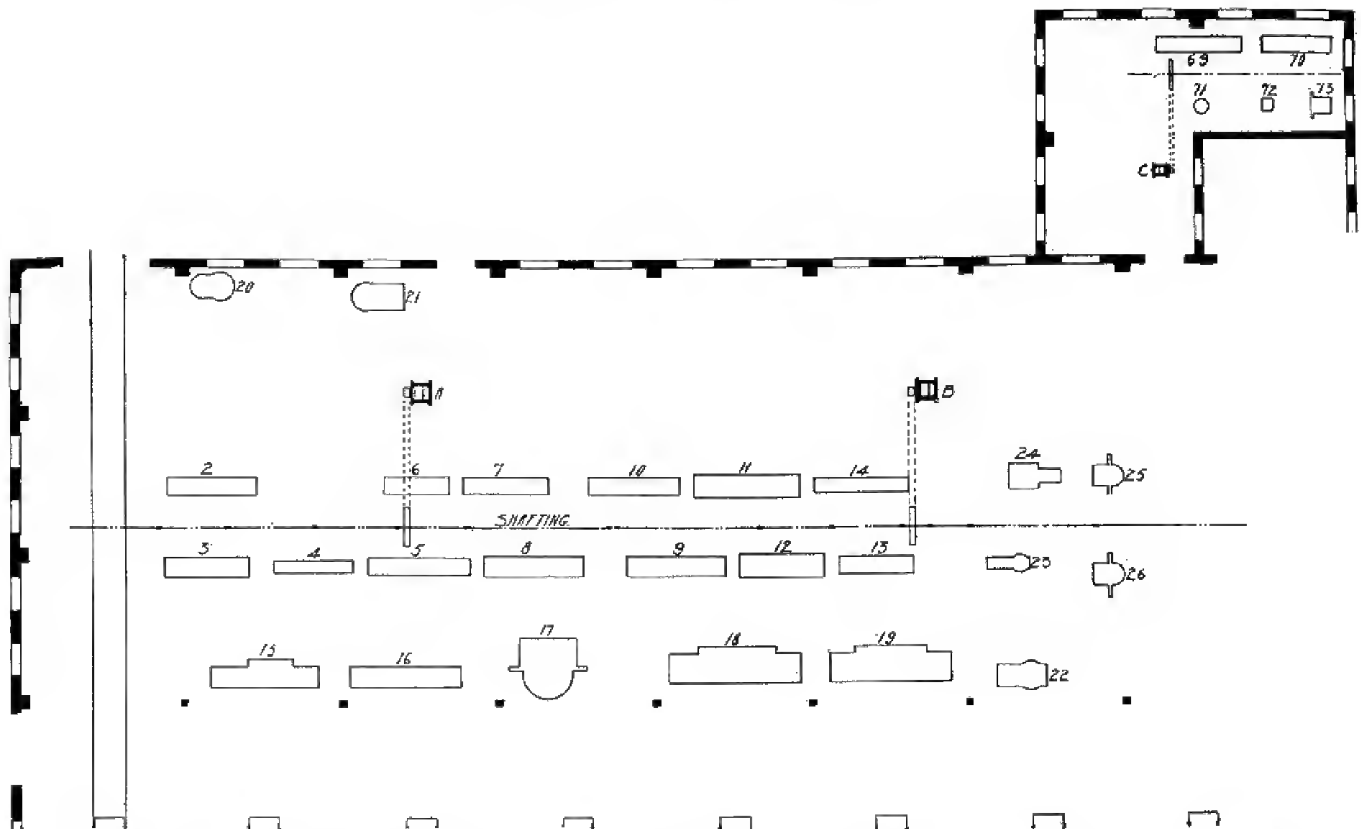


PARTIAL SIDE ELEVATION OF LOCOMOTIVE SHOP AT BEECH GROVE, C. C. C. & ST. L. RY.

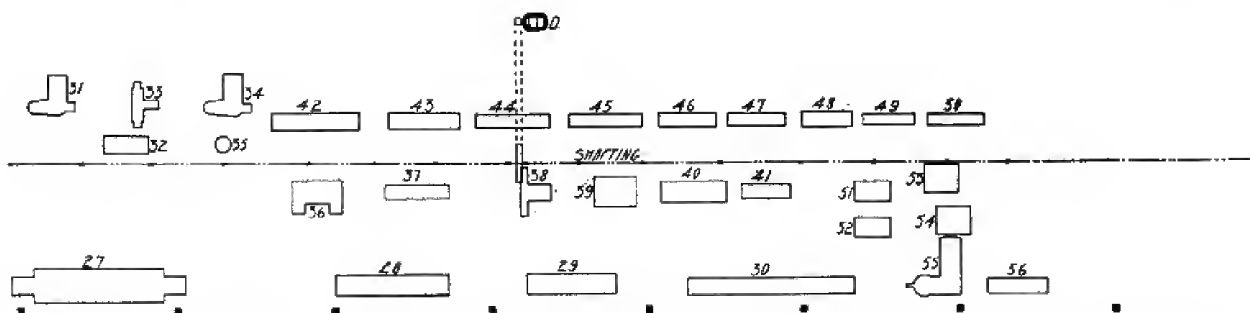


END ELEVATION OF LOCOMOTIVE SHOP AT BEECH GROVE, C. C. C. & ST. L. RY.

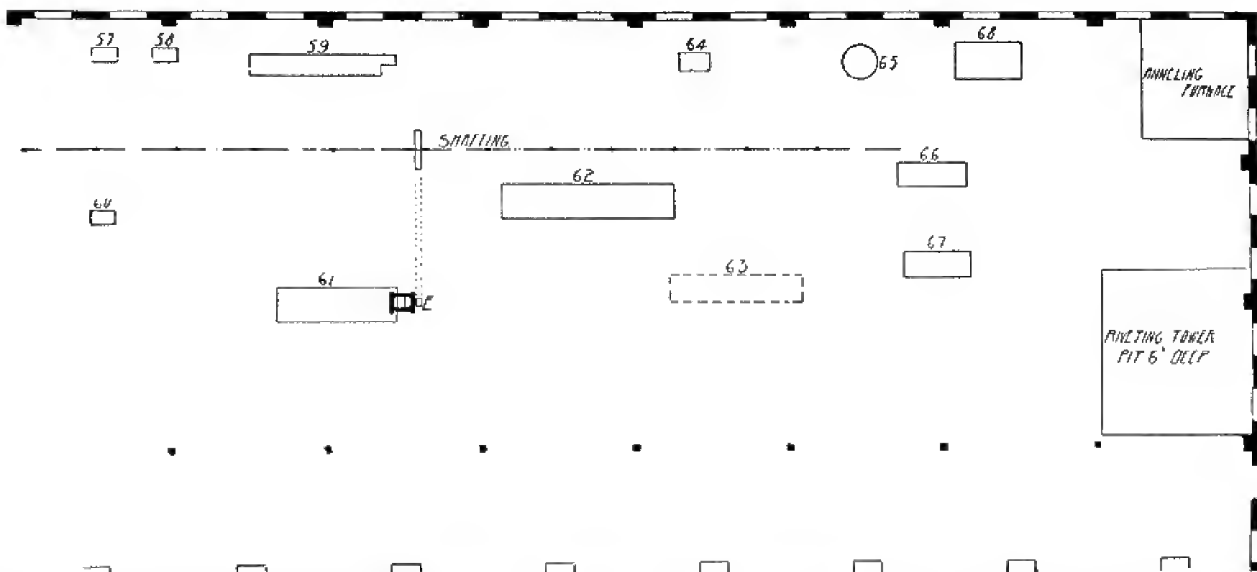
## RAILWAY SHOP UP TO DATE



MACHINE TOOL LAYOUT IN EAST END OF LOCOMOTIVE SHOP AT BARING CROSS, ARK., ST. L. I. M. &amp; S. RY.



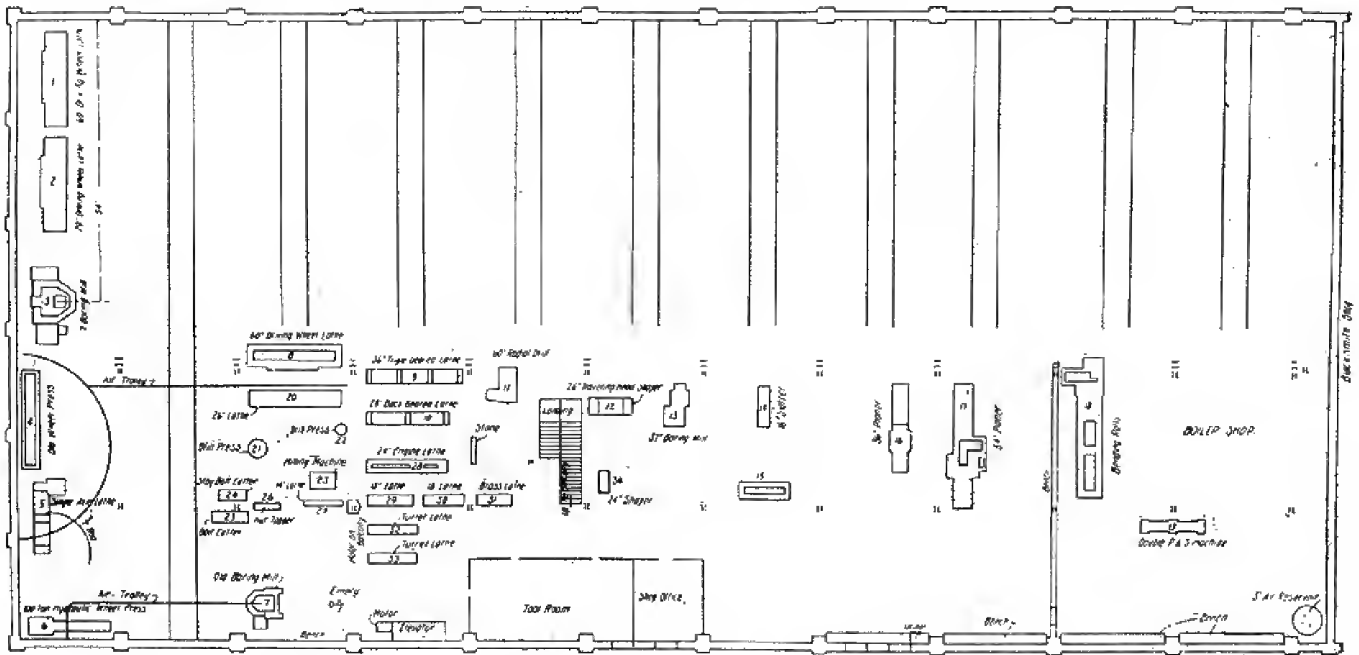
MACHINE TOOL LAYOUT IN CENTRAL BAY OF LOCOMOTIVE SHOP AT BARING CROSS, ARK., ST. L. I. M. &amp; S. RY.



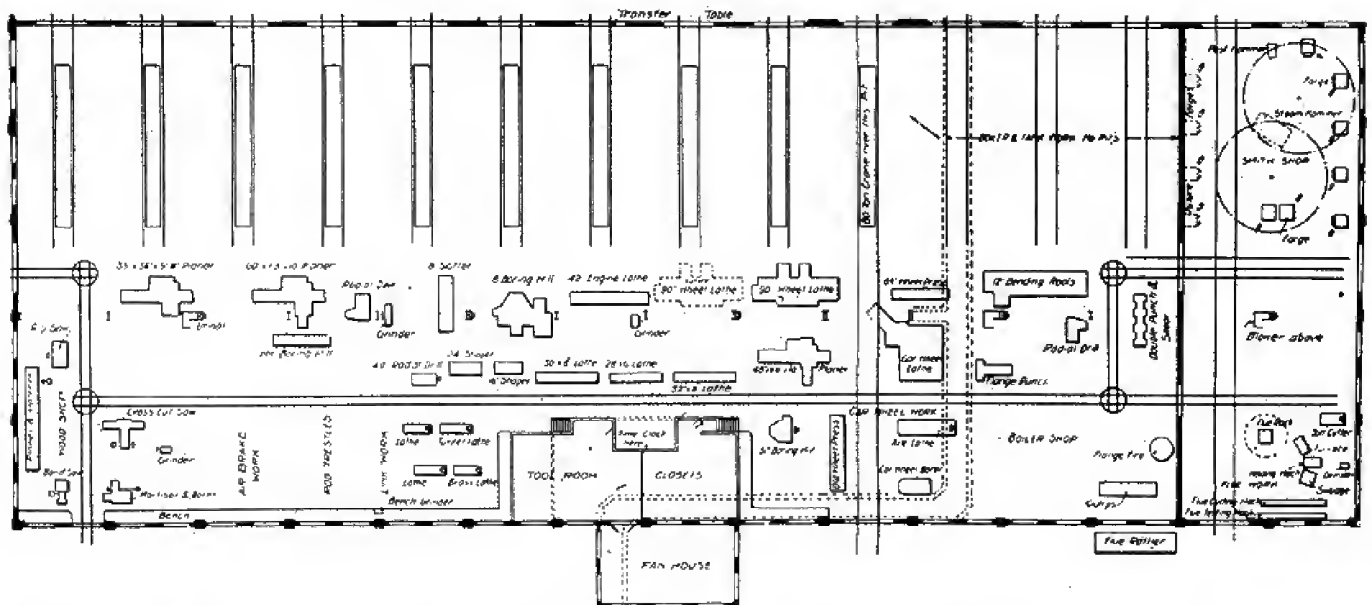
MACHINE TOOL LAYOUT IN BOILER DEPARTMENT, WEST END OF LOCOMOTIVE SHOP AT BARING CROSS, ARK., ST. L. I. M. &amp; S. RY.

LIST OF MACHINE TOOL EQUIPMENT IN LOCOMOTIVE SHOP AT BARING CROSS, ARK., ST. L. I. M. & S. RY.

No.	Description.	No.	Description.	No.	Description.	No.	Description.
1	Wheel press (old).	20	Wheel borer (old).	39	Milling machine (old).	59	Plate planer.
2	Lathe, double end axle (new).	21	Wheel borer (new).	40	Lathe, cabinet (new).	60	Plate shears.
3	Lathe, axle (old).	22	Slotter (old).	41	Lathe, turret (new).	61	Punch and shears (old).
4	Lathe, axle (old).	23	Slotter, 14-in. (new).	42	Lathe, 25-in. (old).	62	Rolls (old).
5	Lathe, axle (new).	24	Horizontal boring mill (old).	43	Lathe, 20-in. (old).	63	Flue rattler, under floor (old).
6	Lathe, 20-in. (old).	25	Boring mill, 37-in. (new).	44	Lathe, 16-in. (new).	64	Flue welder.
7	Lathe, 32-in. (new).	26	Boring mill, 37-in. (new).	45	Lathe, 16-in. (new).	65	Small fire.
8	Lathe, 30-in. (new).	27	Planer, 4-head (old).	46	Lathe, 18-in. (old).	66	Flange clamp.
9	Lathe, 30-in. (new).	28	Planer, 38x38-in. (new).	47	Lathe, turret (new).	67	Face plate.
10	Lathe, 36-in. (new).	29	Planer, 32x32-in. (old).	48	Lathe, turret (old).	68	Flange fire.
11	Lathe, 38-in. (old).	30	Planer, frog (old).	49	Lathe, Fox (old).	69	Lathe, 14-in. (new).
12	Lathe, 32-in. (old).	31	Radial drill, 60-in., rotating arm (new).	50	Lathe, 16-in. (old).	70	Lathe, 14-in. (new).
13	Lathe, 28-in. (old).	32	Drill press (old).	51	Nut tapper (new).	71	Drill, 32-in. (new).
14	Lathe (old).	33	Surface grinder, 24-in. (new).	52	Nut tapper (old).	72	Tool grinder (new).
15	Lathe, car wheel, 28-in. (new).	34	Radial drill, 60-in. (new).	53	Bolt cutter (old).	73	Milling machine (new).
16	Driving wheel press (old).	35	Drill press, 32-in. (new).	54	Bolt cutter (old).	A	Motor, 20-h. p.
17	Boring mill, 7-ft.	36	Shaper, 18-in. (new).	55	Radial drill (old).	B	Motor, 20-h. p.
18	Driving wheel lathe (old).	37	Planer, 26x26-in. (old).	56	Arch bar drill (new).	C	Motor, 3½-h. p.
19	Driving wheel lathe (old).	38	Milling machine (new).	57	Drill press (old).	D	Motor, 30-h. p.
				58	Drill press (old).	E	Motor, 30-h. p.

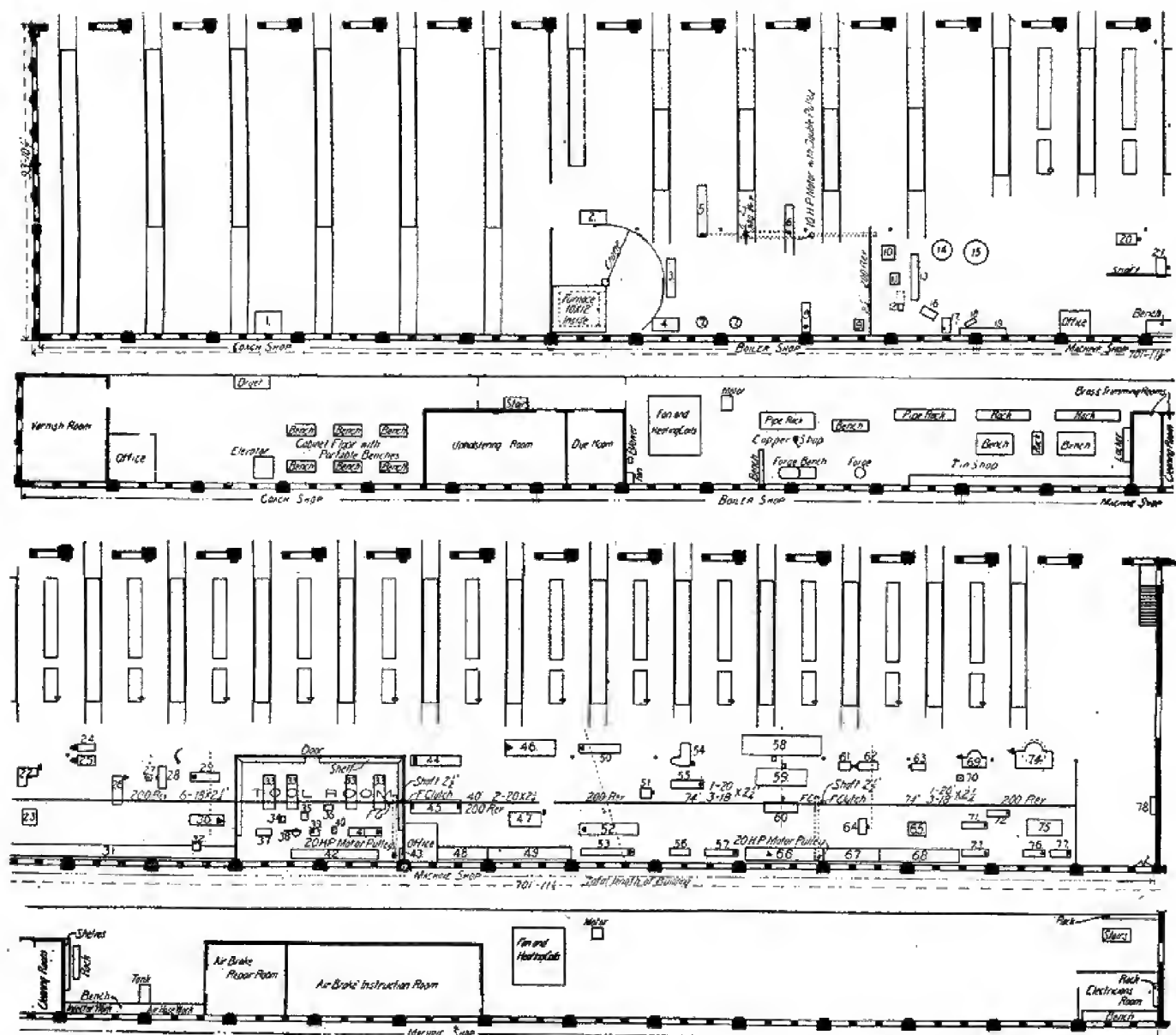


FLOOR PLAN OF LOCOMOTIVE SHOP AT EAST ST. LOUIS, ILL., T. R. R. OF ST. L.—SHOWING LAYOUT OF MACHINE TOOL EQUIPMENT AND ARRANGEMENT OF ERECTING PITS.



FLOOR PLAN OF LOCOMOTIVE SHOP AT GRAND RAPIDS, MICH., P. M. R. R.—SHOWING LAYOUT OF MACHINE TOOL EQUIPMENT AND ARRANGEMENT OF ERECTING PITS.

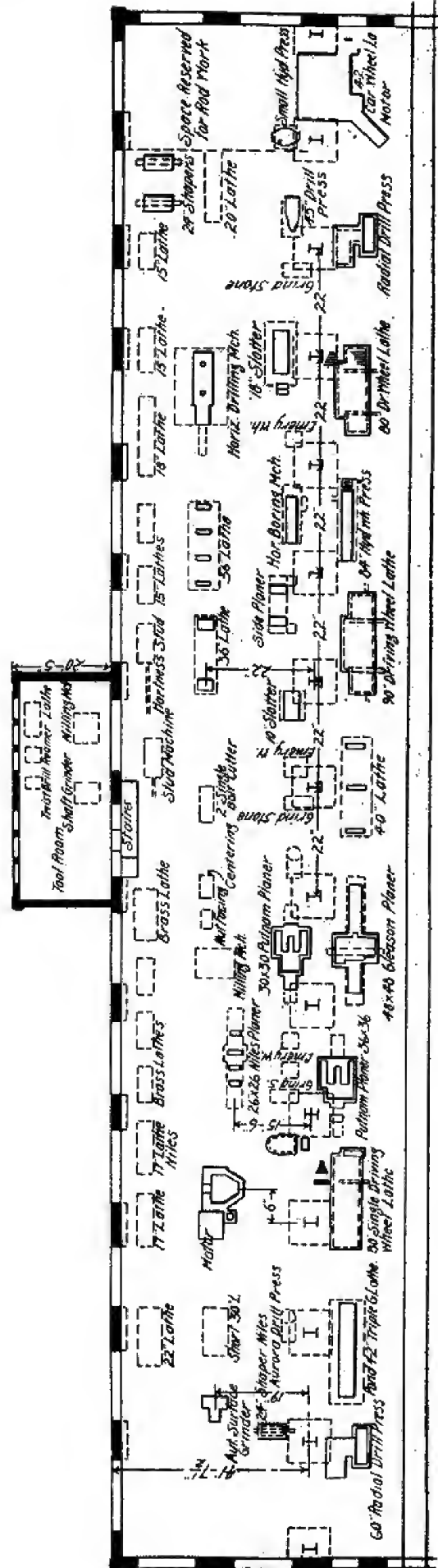
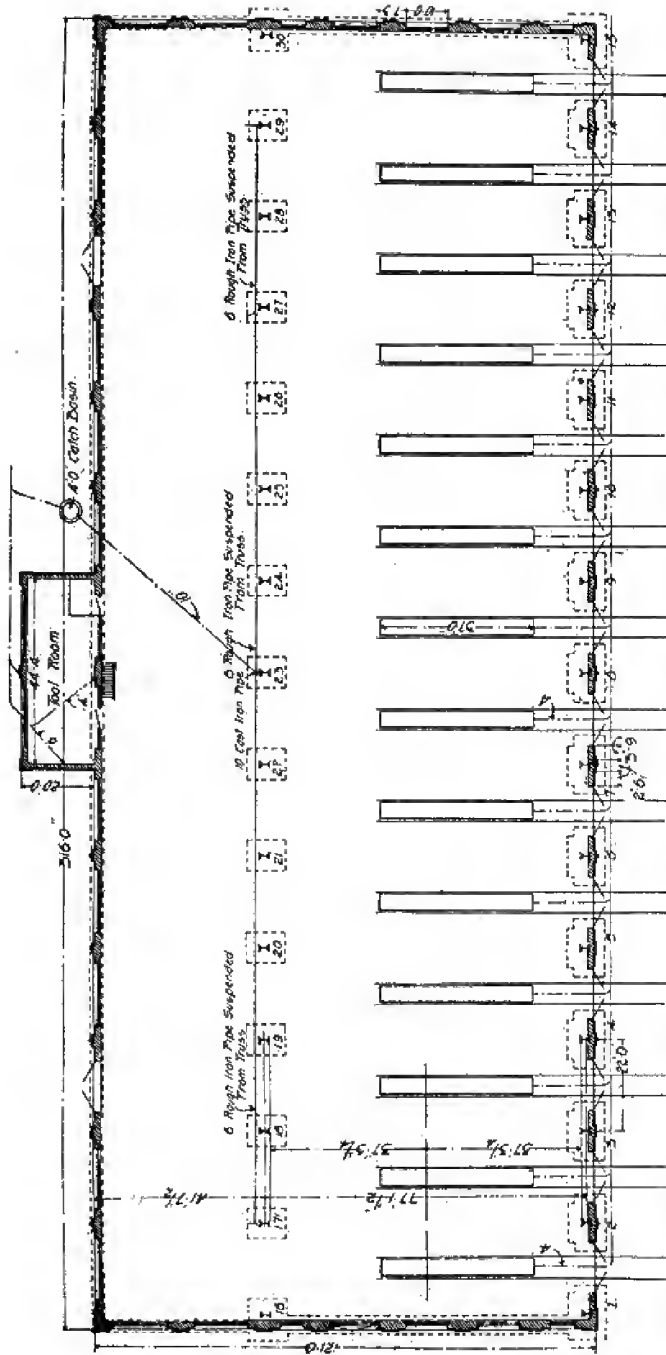
## RAILWAY SHOP UP TO DATE

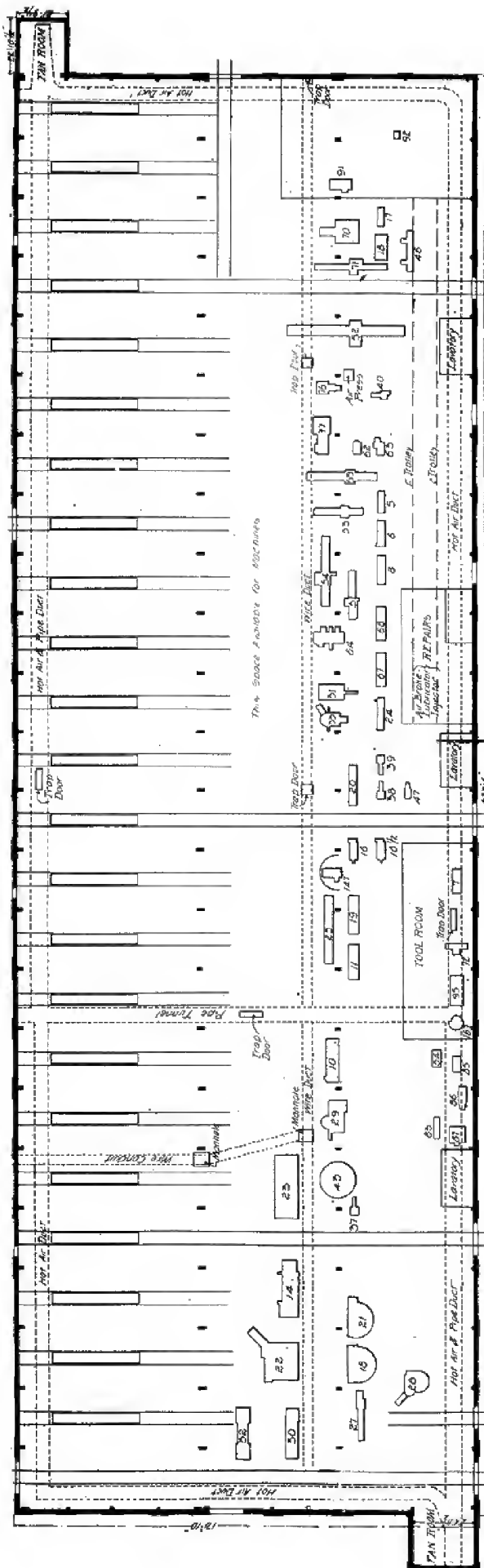


FLOOR PLAN OF LOCOMOTIVE AND CAR SHOP AT OELWEIN, IA., C. G. W. RY.—SHOWING LAYOUT OF MACHINE TOOL EQUIPMENT AND ARRANGEMENT OF ERECTING PITS, AND LOCATION OF AUXILIARY DEPARTMENTS ON BALCONY—THE LOWER ILLUSTRATION SHOULD BE READ AS A CONTINUATION OF THE UPPER.

## LIST OF MACHINE TOOL EQUIPMENT AT OELWEIN, IA., C. G. W. RY.

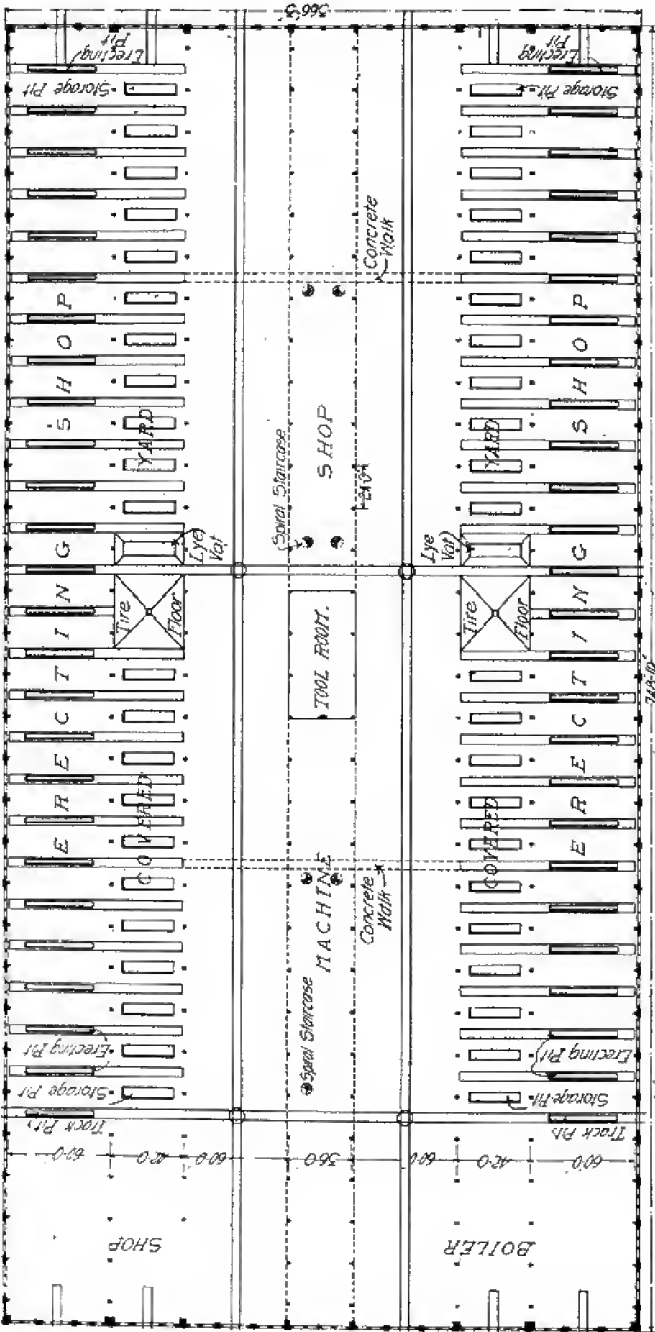
No.	Description.	No.	Description.	No.	Description.	No.	Description.
1	Freight elevator.	21	Grindstone.	41	24-in.x10-ft. lathe, 1½ h. p.	58	60-in.x60-in.x20-ft. planer, 5 h. p.
2	Straightening plate.	22	Cold saw, ½ h. p.	42	Bench.	59	36-in.x36-in.x12-ft. planer, 3 h. p.
3	Flange clamp.	23	Screw press (hand).	43	Cupboard.	60	26-in.x26-in.x6-ft. planer, 2 h. p.
4	Flange fire.	24	Single head bolt cutter.	44	72-in. wheel press, 7 h. p.	61	Drill press, 1 h. p.
5	Power rolls, 8 to 10 h. p.	25	Double head bolt cutter.	45	Quartering machine, 3 h. p.	62	Slotter, 2 h. p.
6	Punch and shears, 5 h. p.	26	Shaper, 1½ h. p.	46	Wheel lathe, 7 h. p.	63	Drill press, 1 h. p.
7	Forges.	27	Emery grinder, 1 h. p.	47	Shaper, 1½ h. p.	64	Grindstone.
8	Flange punch, 2½ h. p.	28	Gulde grinder, 1 h. p.	48	Bench, general uses.	65	Hydraulic press (hand).
9	Drill press.	29	Horizontal borer, 2 h. p.	49	Bench, piston and cross head fitting.	66	Bench for link work.
10	Bevel shears.	30	30-in.x10-ft. lathe, 2 h. p.	50	36-in.x12-ft. 6 in. lathe, 2½ h. p.	67	Bench for eccentric strap work.
11	Drill.	31	Bench for rod work.	51	Small drill press.	68	Bench for driving box fitting.
12	Rattle (under floor).	32	Drill press.	52	25-in.x18-ft. lathe, 1½ h. p.	69	51-in. boring mill, 2 h. p.
13	Flue saw.	33	Racks.	53	30-in.x16-ft. lathe, 2 h. p.	70	Emery grinder, 1 h. p.
14	Flue stand.	34	Grinder.	54	Radial drill, 2 h. p.	71	Turret screw machine, 1 h. p.
15	Annealer.	35	Saw.	55	18-in.x10-ft. lathe, ¾ h. p.	72	Stud lathe, 1 h. p.
16	Furnace.	36	Small drill press.	56	Centering lathe, 1 h. p.	73	Flat turret lathe, 1 h. p.
17	Flue welder.	37	Universal grinder, 1 h. p.	57	20-in.x10-ft. lathe, 1 h. p.	74	84-in. boring mill, 4 h. p.
18	Air swager.	38	Tape grinder, ½ h. p.			75	Rack.
19	Flue tester.	39	Milling machine, 1 h. p.			76	Brass lathe, ¾ h. p.
20	Double head bolt cutter.	40	Grinder, ½ h. p.			77	Brass lathe, ¾ h. p.



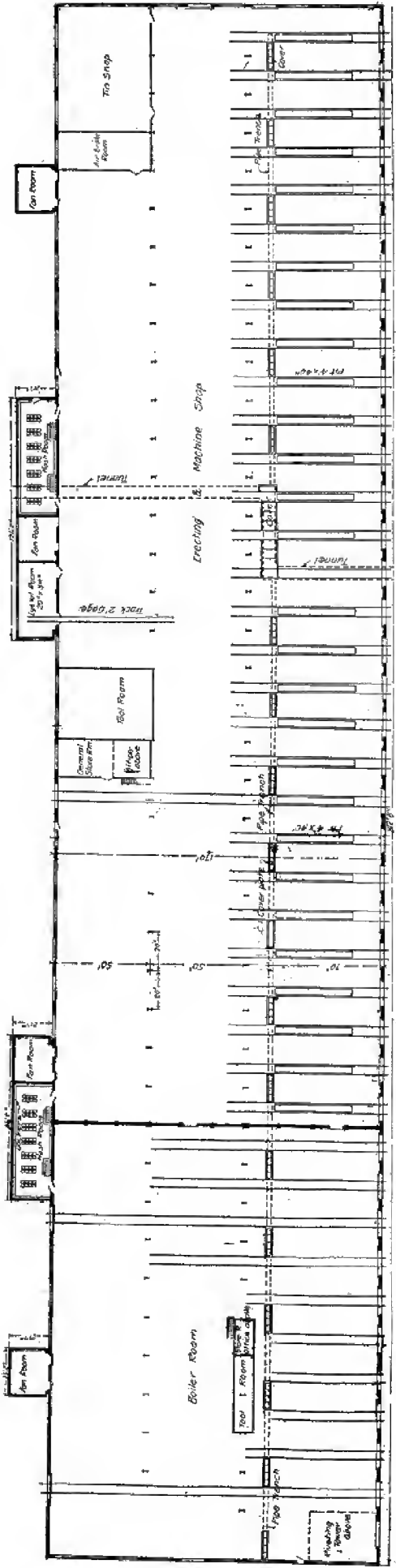


LAY OUT OF MACHINE TOOL EQUIPMENT AND ARRANGEMENT OF PITS IN LOCOMOTIVE SHOP AT MCKEES ROCKS, PA., P. & L. E. R. R.

Mach. No.	Class of Machine	Size	Maker	Motor H. P.
5	Lathe	18-in.	Flather	5
6	Lathe	20-in.	Reed	5
7	Lathe	20-in.	Reed	5
8	Lathe	25-in.	Putnam	7½
10	Lathe	25-in.	Niles	15
11	Lathe	42-in.	Reed	7½
13	Double Axle Lathe	24-in.	Reed	25
14	Driv. Wheel Lathe	72-in.	Jones & Lamson	5
16	Turret Lathe		Jones & Lamson	5
18	Brass Tur. Lathe		Jones & Lamson	5
19	Lathe	18-in.	Am. Tool & Mach. Co.	3
20	Lathe	24-in.	American	7½
21	Double Head Axle Lathe	30-in.	Putnam	10
22	Steel Tire Wheel Lathe		Putnam	35
23	Driv. Wheel Lathe	90-in.	Pond	30
24	Lathe	18-in.	Putnam	25
25	Lathe	38-in.	Putnam	7½
27	Wheel Press		Niles	10
28	Car Wheel Borer		Niles	7½
29	Boring Mill		Pond	10
30	Wheel Press	72-in.	Pond	25
31	Horz. Bor. Mach.	100-in.	Putnam	7½
32	Quartering and Ptn Turning Machine		Betts	15
33	Vertical Bore and Turning Mill	51-in.	Niles	5
			Baush	15
37, 38, 39, 40	Vertical Drill Presses	6-ft.		4
43	Radial Drill			4
45	Multiple Rod Drill			9½
47	Vertl Drill Press	30-in. table	Bement	5
51	Planer	30x30 in.x8 ft.	Snyder	90
52	Planer	30x30 in.x20 ft.	Pond	7½
53	Planer	30x30 in.x8 ft.	Fowell	15
54	Planer	42x42 in.x15 ft.	Cincinnati	15
55	Planer	42x42 in.x12 ft.	Pond	5
62	Shaper	12-in.		7½
63	Shaper	24-in.	Cincinnati	7½
64	Shaper	24-in.	Putnam	7½
67, 68	Lathes	20-in.		15
70	Turret Lathe	34-in.	Gisholt	6½
71	Slab Miller			6½
72	Milling Machine			13
76	Slotter	12-in.	Betts	
77	Slotter	16-in.	Putnam	
83	Bolt Cutter			
84	Bolt Cutter			
85	Bolt Cutter			
86	Nut Tapper	6-spindle		
87	Staybolt Cutter	4 heads		
91	Pipe Cutter		Saunders	7½
92	Spec'l Pipe Cutter			
93	Twist Drill Grinder			
95	Universal Grinder			
107	No. 1 Tool Grinder		Sellers	
108	Power Hack Saw	5-ft. radius		6½
147	Radial Drill			

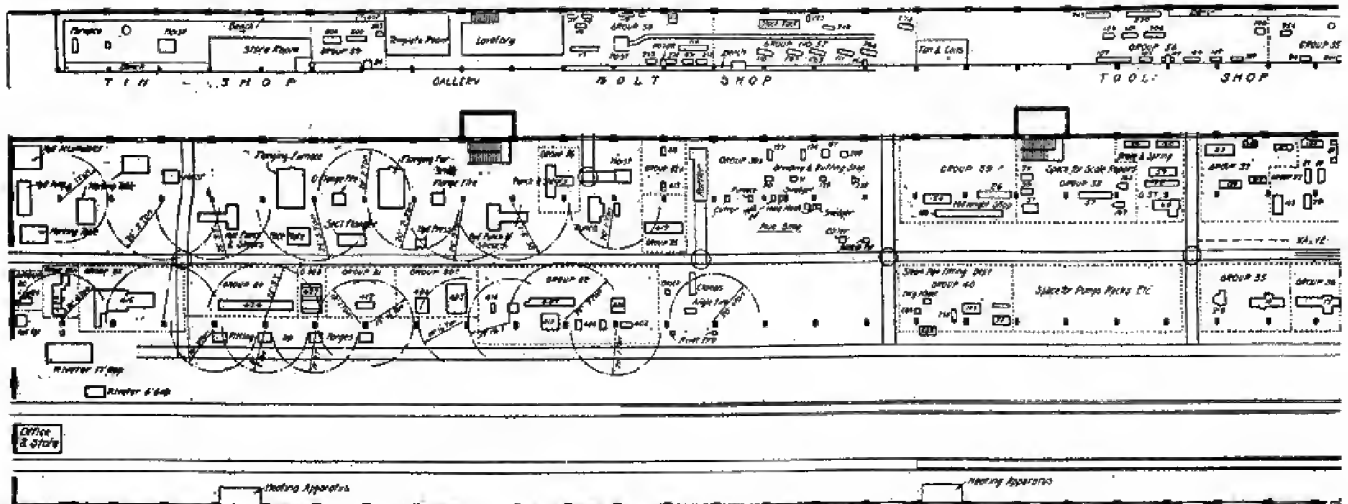


FLOOR PLAN OF LOCOMOTIVE SHOP AT SAYRE, PA., L. V. R. R.



FLOOR PLAN OF LOCOMOTIVE SHOP AT SOUTH LOUISVILLE, KY., L. & N. R. R.

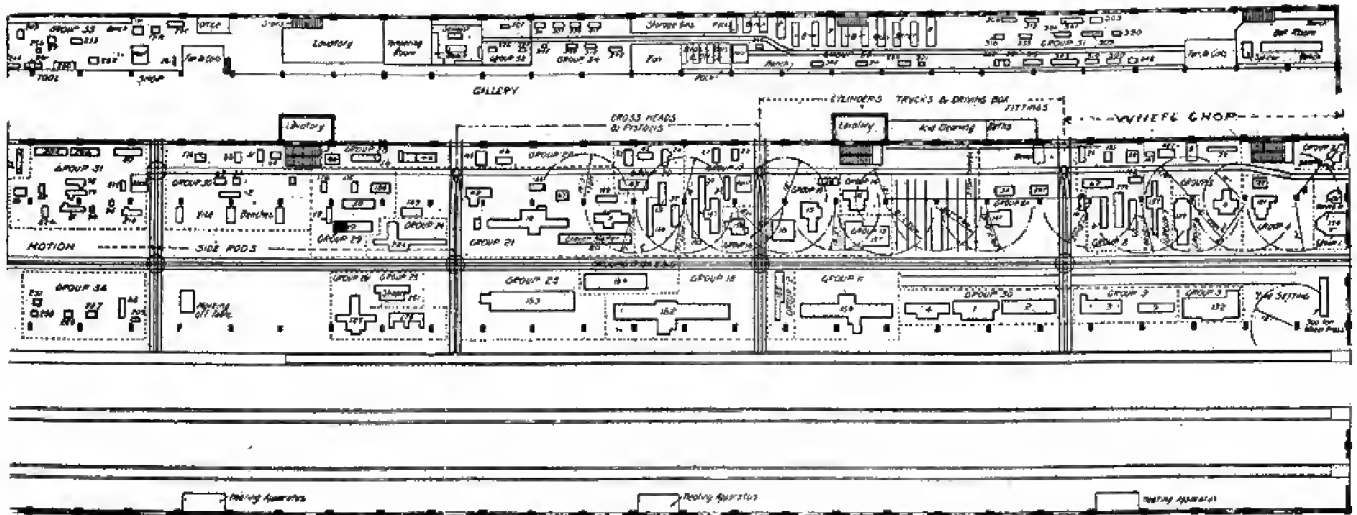
## RAILWAY SHOP UP TO DATE



LAY OUT OF MACHINE TOOL EQUIPMENT AND ARRANGEMENT OF PITS IN LOCOMOTIVE SHOP AT ANGUS, C. P. RY.

## LIST OF MACHINE TOOL EQUIPMENT IN LOCOMOTIVE SHOP AT ANGUS, C. P. RY.

Mach. No.	Class of Machine.	Size.	Maker.		Mach. No.	Class of Machine.	Size.	Maker.	
178	Side Rod Drill	3 Spindles	Bertram		93	Double Shaper	6-in.	Craven Bros.	
	Vertical Drill	36-in.	Bertram	20 A.C.	182	Turret Lathe	3 in.x36 in.	Pratt & Whitney	
	Vertical Drill	24-in.	Bertram			Turret Lathe	2 in.x24 in.	A. Herbert	
123	Miller	5 ft.x5 ft.x12 ft.	Ingersoll	2-5 A.C.	217	Horz. Boring Mill	3-in. bar	Bement Miles	15 A.C.
251	Side Rod Shaper	24-in.—2 heads	Bertram		200	Cutting-Off Mach.	5-in.	Bertram	
284	Double Planer	4 ft.x4 ft.x14 ft.	Pond	15 A.C.	33	Hor. Boring Mach.		Craven Bros.	
149	Turret Lathe	5-in.		2-2 A.C.	48	Radial Drill	5-ft.	Hulse & Co.	
	Vertical Drill	40-in.	Bardons & Oliver		192	Engine Lathe	24 in.x8 ft.	Bertram	
19	Double Slotter	12-in. stroke	Bement Miles		59	Double Shaper	14-in.		
50	Double Drill		Bertram	20 A.C.	29	Engine Lathe	20 in.x5 ft.		
176	Vertical Drill	36-in.	Craven Bros.		190	Engine Lathe	30 in.x6 ft.	Bertram	10 A.C.
184	Slotter	16-in.	Craven Bros.			Vertical Drill	46-in.	Bertram	
44	Double Planer		Bertram		168	Vertical Drill	36-in.	Bertram	
56	Cotter Mill	4-Spindle			169	Vertical Drill	36-in.	Bertram	
166	Vertical Drill	40-in.	Bement Miles	10 A.C.	59	Double Drill		Bertram	
175	Vertical Drill	24-in.				Screwing Machine	3-in.	Smith & Beacock	
60	Shaper	12-in.	Bertram		4	Spindle Drill	Up to 1/2 in.	Footo Burt.	10 A.C.
61	Shaper	24-in.	Bertram		37	Slotter	12-in.	W. Collier	
66	Crank Planer	18 in.x18 in.x18 in.	Craven Bros.		39	Slotter	10-in.	W. Collier	
64	Chucking Lathe	24-in.	Craven Bros.		38	Slotter	10-in.	W. Collier	
62	Engine Lathe	16 in.x5 ft.x6 in.	Craven Bros.	20 A.C.		Emery Grinder	20-in. wheel	Can. Pac. Ry.	
63	Chucking Lathe	24-in.	Niles		189	Engine Lathe	24 in.x22 ft.	Bertram	15 A.C.
174	Turret Boring Mill	30-in.	McGregor		26	Engine Lathe	24 in.x9 ft.	Smith & Coventry	
	Engine Lathe	20 in.x5 ft.	Bridgeport Co.		154	Horz. Boring Mach.	4 in.x9 ft.	Bertram	
	Suspended Emery Wheel	20-in.				Engine Lathe	18 in.x3 ft. 6 in.	LeBlond	
68	Side Bar Grinder		Bertram		55	Vertical Drill	36-in.	Bertram	
	Engine Lathe	12 in.x2 ft. 6 in.	Smith & Coventry		285	Pipe Threader	10-in.	Cox & Sons	15 A.C.
227	Link Grinder	5-ft. radius	Smith & Coventry		235	Pipe Threader	4-in.	Williams Tool Co.	
	Grindstone	6-ft.	Niles B. Pond	20 A.C.	236	Pipe Threader	4-in.	Armstrong	
236	Double Buffer	30 in.x8 in.	Niles B. Pond			Emery Wheel	12-in.	Can. Pac. Ry.	
214	Emery Grinder	20-in. wheel	Can. Pac. Ry.		282	Emery Grinder	20-in. wheel	Can. Pac. Ry.	
	Lapping Lathe					Emery Grinder	20-in. wheel	Can. Pac. Ry.	
231	Grinder	Lea No. 1	Anderson T. Co.	2 small D.C.		Tool Grinder	No. 2	Sellers	
81	Engine Lathe	24 in.x5 ft. 4 in.	M'Greg. & Gourlay		111	Drill Grinder	No. 1	Sellers	
224	Shaper	24-in.	Flather			Tool Grinder		Cincinnati	
79	Engine Lathe	18 in.x5 ft.	Bertram		252	Universal Miller		LeBlond	
78	Engine Lathe	16 in.x5 ft.	Gardner		255	Vertical Drill	30-in.	Bertram	
92	Shaper	4-in.			250	Universal Grinder	No. 7	Landis	20 A.C.
206	Engine Lathe	24 in.x6 ft.	Bertram		99	Plain Miller		Bertram	
204	Engine Lathe	30 in.x8 ft. 6 in.	Bertram			Engine Lathe	22 in.x3 ft. 6 in.	LeBlond	
210	Engine Lathe	18 in.x3 ft. 6 in.	LeBlond	20 A.C.	241	Engine Lathe	20 in.x4 ft. 6 in.	LeBlond	
95	Vertical Drill	20-in.	Craven Bros.		244	Engine Lathe	14 in.x2 ft. 8 in.	Pratt & Whitney	
96	Vertical Drill	20-in.	Craven Bros.			Disc. Grinder	No. 1	Chas. Besly	
225	Shaper	16-in.	Bertram			Shaper	24-in.	Flather	
	Centering Machine		D. E. Whiton		254	Vertical Drill	30-in.	Bertram	
	Engine Lathe	22 in.x3 ft. 6 in.				Tool Grinder	6-in. wheel		
86	Vertical Drill	36-in.	Craven Bros.		94	Double Shaper	4-in.	Craven Bros.	
17	Planer	4 ft.x4 ft.x12 ft.	Flather	20 A.C.	100	Universal Miller	No. 3	Cincinnati	
	Vertical Drill	24-in.	Craven Bros.			Turret Lathe	2 in.x24 in.	Jones & Lamson	
88	Vertical Drill	36-in.	Craven Bros.		109	Engine Lathe	16 in.x3 ft.	Gardner	
84	Planer	2 ft.x2 ft.x6 ft.	Bertram		105	Engine Lathe	14 in.x3 ft.	Smith & Coventry	
83	Planer	2 ft.x2 ft.x4 ft.	Craven Bros.	15 A.C.	104	Engine Lathe	16 in.x2 ft.		
231	Vertical Drill	36-in.	Bertram		103	Engine Lathe	16 in.x3 ft.	Gardner	
183	Slotter	16-in.	Bertram		103	Engine Lathe	16 in.x3 ft.	Brown & Sharpe	
87	Vertical Drill	36-in.	Bertram		105	Engine Lathe	16 in.x4 ft. 6 in.	Smith & Coventry	20 A.C.
124	Engine Lathe	24 in.x5 ft. 8 in.	Gardner		107	Engine Lathe	24 in.x10 ft.	Bertram	
10	Extension Lathe	36 in.x72 in.x10 ft.	Bertram	10 A.C.	101	Engine Lathe	12 in.x3 ft.	Smith & Coventry	
218	Boring Mill	51-in.	Niles		243	Hack Saw		Patterson Tool Co.	
					230	Engine Lathe	13 in.x9 ft.	LeBlond	
					102	Engine Lathe	10 in.x3 ft.	Whitworth	
						Wet Grinder	42-in. wheel	Bridgeport	

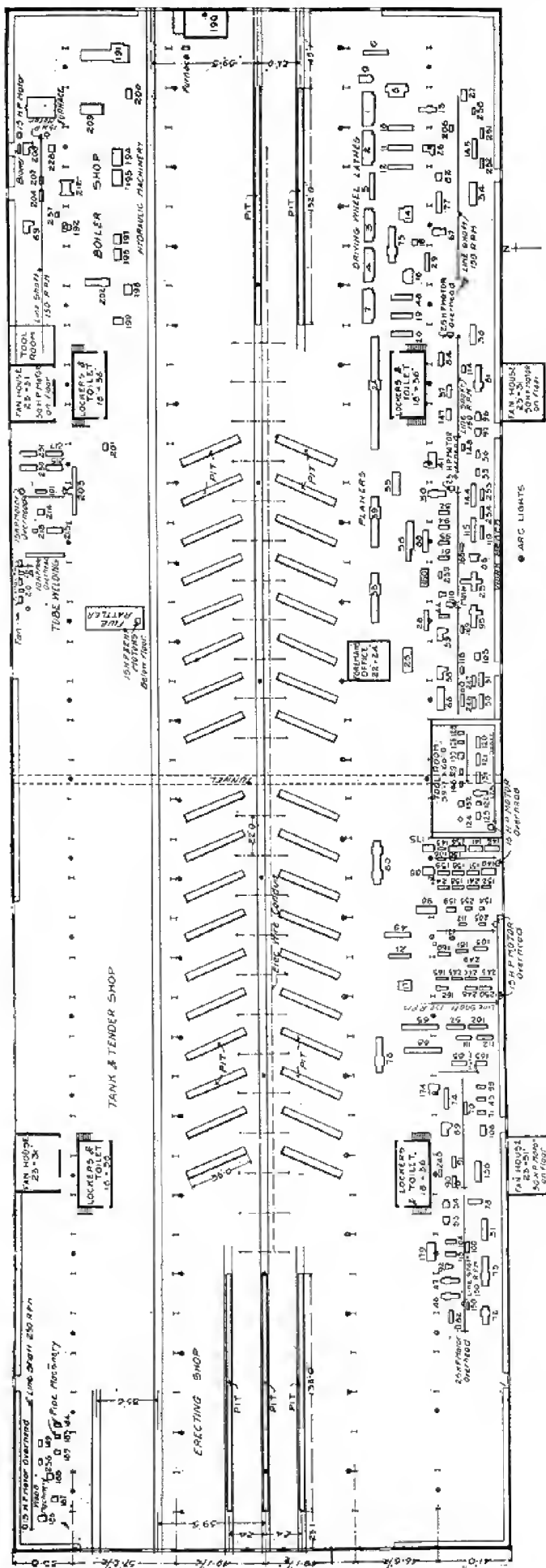


LAYOUT OF MACHINE TOOL EQUIPMENT AND ARRANGEMENT OF PITS IN LOCOMOTIVE SHOP AT ANGUS, C. P. RY.

## LIST OF MACHINE TOOL EQUIPMENT IN LOCOMOTIVE SHOP AT ANGUS, C. P. RY.

Mach. Class of No. Machine.	Size	Maker.	No. Machine.	Mach. Class of	Size.	Maker.
Wheel Press.....300 tons		Bertram	10 A.C.	164 4-Spindle Drill....For Frames.....	Bement Miles.....	4-5 D.C.
134 Boring Mill.....90-in.		Niles	20 D.C.	11 Extension Lathe...36 in.x72 in.x10 ft.	Bertram.....	
51 Boring Mill.....51-in.		Bullard	10 D.C.	88 Horz. Boring Mill.4 in. barx9 ft.	Hinsse.....	
121 Boring Mill.....64-in.		Bertram	7.5 D.C.	18 Planer.....5 ft.x5 ft.x20 ft.	Bertram.....	
122 Car Wheel Borer.....				67 Vertical Miller...No. 6	Becker Brainard.....	30 A.C.
28 Engine Lathe.....30 in.x4 ft.		Pond	15 A.C.	Emery Grinder.....20-in. wheel	Niles-Bett Pond.....	
145 Emery Wheel.....20-in. wheels		Niles-Bett Pond		49 Radial Drill.....5-ft.	Hulse & Co.....	
146 Wheel Lathe.....90-in.		Niles	3 A.C. & 30 A.C.	46 Shaper.....24-in.	Flather.....	
8 Boring Mill.....84-in.		Craven Bros.	15 A.C.	165 Crank Planer.....2 ft.x2 ft.x2 ft.	Craven Bros.....	10 A.C.
9 Quarter's Machine90-in.		Bertram	2-5 A.C.	156 Cotter Drill.....No. 3	Bement Miles.....	
139 Planer.....4 ft.x4 ft.x12 ft.		Bertram	20 A.C.	163 Triple Slotter.....24-in. stroke	Bertram.....	20 A.C.
137 Horz. Miller.....42 in.x42 in.x14 ft.		Bement Miles	20 D.C.	20 Triple Slotter.....8-in. stroke		10 A.C.
6 Axle Lathe.....						
259 Axle Lathe.....14 in.x8 ft.		Bertram				
6 Axle Lathe.....						
140 Shaper.....24-in. stroke		Niles	30 A.C.			
42 Planer.....32 in.x32 in.x8 ft.		Craven Bros.				
185 Shaper.....14-in. stroke		Craven Bros.				
21 Boring Mill.....37-in.		Niles				
14 Radial Drill.....4-ft.						
3 Wheel Lathe.....72-in.		Bertram				
2 Wheel Lathe.....84-in.		German Niles				
1 Wheel Lathe.....84-in.		Bertram	30 A.C.			
4 Wheel Lathe.....60-in.		Bertram				
141 Slotter.....20-in. stroke		Bertram				
237 Vertical Drill.....50-in.		Bement Miles	10 A.C.			
34 Slotter.....14-in.		Craven Bros.				
Cylinder and Frame Department.						
158 Planer.....6 ft.x6 ft.x22 ft.		Pond	30 A.C.			
157 Radial Drill.....9-ft.		Bement Miles	5 A.C.			
15 Radial Drill.....6-ft.		Bertram	5 A.C.			
13 Planer.....5 ft.x5 ft.x8 ft.		Sharp, Stewart Co.				
16 Cylinder Borer.....		Craven Bros.				
36 Slotter.....14-in. stroke		Newton	30 A.C.			
Engine Lathe.....24 in.x5 ft.		Lodge & Shipley				
Slotter for valve bush.....5-in. stroke		Can. Pac. Ry.				
155 Cylinder Borer...3 bars		Bement Miles	10 D.C.			
150 Boring Mill.....60-in.		Niles	10 D.C.			
23 Chucking Lathe.....30-in.		Craven Bros.				
147 Extension Lathe...36 in.x72 in.x10 ft.		Bertram				
193 Engine Lathe.....36 in.x9 ft.x6 in.		Pond	20 A.C.			
80 Engine Lathe.....24 in.x7 ft. 6 in.		Bertram				
22 Chucking Lathe.....30-in.		Craven Bros.				
162 Planer, Frame.....6 ft.x6 ft.x32 ft.		T. N. Shanks	20 A.C.			
82 Chucking Lathe.....36-in.		Craven Bros.				
148 Engine Lathe.....30 in.x10 ft.		Pond				
25 Engine Lathe.....30 in.x5 ft.		Stewart				
43 Planer.....32 in.x32 in.x8 ft.		Craven Bros.	20 A.C.			
24 Chucking Lathe.....24 in.x4 ft.		Bertram				
45 Crank Planer.....24 in.x24 in.x24 in.		Craven Bros.				
62 Drill.....36-in.		Craven Bros.				
Brass Department.						
				348 Engine Lathe.....12 in.x3 ft. 9 in.	Bertram	
				343 Turret Lathe.....24-in.	Am. Tool Co.	
				335 Forming Lathe.....18-in.	Warner & Swasey	
				300 Engine Lathe.....20 in.x2 ft. 6 in.	Bertram	
				309 Turret Lathe.....24-in.	Smith & Coventry	
				303 Turret Lathe.....14-in.	Bertram	
				310 Engine Lathe.....24 in.x4 ft. 8 in.	LeBlond	
				304 Turret Lathe.....20-in.	Bertram	
				341 Turret Lathe.....22-in.	Bullard	
				313 Turret Lathe.....20-in.	Warner & Swasey	20 A.C.
				302 Valve Miller.....2 Spindles	Warner & Swasey	
				301 Chucking Lathe.....15-in.	Smith & Coventry	
				215 Chucking Lathe.....16-in.	Smith & Coventry	
				Turret Lathe.....16-in.	Smith & Coventry	
				316 Turret Lathe.....16-in.	Warner & Swasey	
				306 Turret Lathe.....16-in.	Smith & Coventry	
				Emery Grinder.....6-in. wheel	Can. Pac. Ry.	
				320 Saw.....	Can. Pac. Ry.	
				321 Valve Grinder.....	Warner & Swasey	
				244 Vertical Drill.....30-in.	Bertram	
				314 Forming Lathe.....16-in.	Warner & Swasey	10 A.C.
				305 Turret Lathe.....1 in.x10 in.	Pratt & Whitney	
				Disc Grinder.....No. 4	Charles Besly	
				343 Sensitive Drill.....	Can. Pac. Ry.	
				312 Speed Lathe.....13-in.	Am. Tool Co.	
				336 Turret Lathe.....16-in.	Warner & Swasey	
				308 Speed Lathe.....13-in.	Am. Tool Co.	
				307 Turret Lathe.....16-in.	Smith & Coventry	10 A.C.
				Turret Lathe.....16-in.	Niles-Bett Pond	
				317 4-Spindle Drill...To 1/2 in.	Foots Burt	
				311 Turning Lathe.....14-in.	Am. Tool Co.	
				324 Buffer.....	Can. Pac. Ry.	
				326 Buffer.....	Can. Pac. Ry.	
				322 Buffer.....	Tacker Levett	20 A.C.
				Buffer.....	Dickerman	





LAY OUT OF MACHINE TOOL EQUIPMENT AND ARRANGEMENT OF ERECTING PITS IN ERECTING SHOP AT SILVIS ILL., C. R. I. & P. RY.

LIST OF MACHINE TOOL EQUIPMENT IN LOCOMOTIVE SHOP  
AT SILVIS, ILL., C. R. I. & P. RY.

Mach. No.	Class of Machine.	Size.	Maker.	H.P. Motor.
1	Driving Wheel with Quart'g Attach.	79-in.	Niles	15
2	Driv. Wheel Lathe, Double Head.	79-in.	Niles	15
3	Driv. Wheel Lathe, Double Head.	69-in.	Niles	15
4	Driv. Wheel Lathe, Double Head.	69-in.	Niles	15
5	Hydraulic Wheel Press	84-in.	Chicago Shops	10
6	Hydraulic Car Wheel Press	42-in.	Niles	5
7	Driv. Wheel Lathe	90-in.	Chicago Shops	15
8	Steel Tire Car Wheel Lathe	42-in.	Pond	10
9	Car Wheel Boring Machine	42-in.		5
10	Locomotive Axle Turning Lathe			15
11	Double Axle Lathe			15
12	Single Axle Lathe			10
13	Horz. Milling Mach. for Keyways		Beaman & Smith	
14	Double Head Vertical Bor'g Mach.	84-in.		10
16	Double Head Boring Machine	72-in.		10
17	Double Head Boring Machine	60-in.		7½
18	Key Seater Mach.	No. 3	Grant, Mitts & Mer.	
19	Engine Lathe	32 in.x12 ft.		5
20	Engine Lathe	32 in.x12 ft.		5
21	Engine Lathe	32 in.x14 ft.		5
22	Portable Crank Wheel Press		Watson & Stillman	
23	Duplex Mill'g Mch.		Beaman & Smith	
24	Double Head Frame Planer	54 in.x34 ft.		20
25	Horizontal Boring Machine	No. 4	Bement	
26	Radial Drill Press	5-ft.	Niles	
27	Drill Press	40-in.	Aurora	
28	Double Shaping Machine	20 in.x12 ft.	Bement	
29	Double Shaping Machine	20 in.x12 ft.	Bement	
30	Planer	30 in.x30 in.x6 ft.		
31	Engine Lathe	30 in.x12 ft.	Chicago Shops	
32	Pillar Shaper	30-ft.	Cincinnati	
33	Cylinder Planer	60 in.x60 in.x16 ft.	Chicago Shops	20
34	Slotter	24-in.	Chicago Shops	
35	Slotter	18-in.	Bement	15
36	Slotter	13-ft.	Niles	
37	Drill Press	40-ft.	Aurora	
38	Locomotive Cylinder Borer		Bement	10
39	Locomotive Cylinder Planer	72 in.x84 in.x16 ft.		27½
41	Radial Drill, with Tapping Attach.	72-in.	Niles	
43	Portable Valve Seat Miller			
44	Draw Stroke Shaper	24-in.	Morton	
45	Draw Stroke Shaper	30-in.	Morton	
46	Planer	30 in.x30 in.x6 ft.		
47	Planer	30 in.x30 in.x6 ft.		
48	Triple Geared Lathe	36 in.x12 ft.		5
49	Triple Geared Lathe	36 in.x14 ft.		5
50	Back Geared Engine Lathe	18 in.x3 ft.	Lodge & Shipley	
51	Back Geared Engine Lathe	18 in.x3 ft.	Lodge & Shipley	
52	Back Geared Engine Lathe	18 in.x10 ft.	Lodge & Shipley	
53	Double Head Vertical Bor'g Mill	37-in.	Niles	
54	Double Head Vertical Bor'g Mill	37-in.	Niles	
55	Vert. Turret Bor'g and Turn'g Mch.	30-in.	Niles	
56	Vert. Turret Bor'g and Turn'g Mch.	30-in.	Niles	
57	Radial Drill	60-in.	Niles	
58	Radial Drill	60-in.	Niles	
59	Drill Press	40-in.	Aurora	
61	Pillar Shaper	24-in.	Cincinnati	
62	Double Head Vert. Boring Mill	37-in.	Niles	
65	Engine Lathe	46 in.x16 ft.		
66	Horz. Drilling and Boring Machine	No. 2	Bement	
67	Planer	36 in.x36 in.x8 ft.	Bement	
68	Engine Lathe	42 in.x16 ft.		
70	Drill Press	40-in.	Aurora	
71	Shaper	24-inch.	Cincinnati	
72	Planer	30 in.x30 in.x3 ft.		
73	Planer	30 in.x30 in.x16 ft.		
74	Engine Lathe	24 in.x12 ft.		
75	Planer	48 in.x48 in.x12 ft.	Pond	15
76	Planer	48 in.x48 in.x12 ft.	Pond	15
77	Engine Lathe	24 in.x12 ft.		
78	Guide Bar Grinder	84-in.	Springfield	
79	Portable Wrist Pin Machine		Pedrick & Ayer	
80	Rad Planer	38 in.x38 in.x18 ft.		15

81 Planer	38 in.x48 in.x12 ft.	Niles	241-247 Engine Lathe.16 in.x6 ft.	Lodge & Shipley
82 Slotter	14-in.	Niles	248-254 Engine Lathe.14 in.x6 ft.	Lodge & Shipley
83 Slotter	14-in.	Niles	169 Radial Drill	60-in. Niles
84 Slotter	14-in.	Niles	101 Drill Press	28-in. Aurora
85 Drill Press	50-in.	Niles	149 Drill Press	21-in. Hoefler
86 Universal Milling Machine	No. 3	Becker-Brainerd	183 Pipe Machine	1-in. to 2-in. Jarecki
87 Portable Bushing Press	20-Ton	Watson & Stillman	184 Pipe Machine	1½ in.x4 in. Forbes
88 Back Geared Engine Lathe	32 in.x12 ft.	Pond	186 Band Saw	36-in. Carse
89 Radial Drill	60-in.	Niles	187 Combined Rip and Cut-off Saw	
90 Drill Press	40-in.	Aurora	188 Hand Joiner	Fay
91 Drill Press	40-in.	Bement	189 Single Spindle Vertical Borer	No. 2 Bement
92 Planer	24-in.	Cincinnati	190 Hydraulic Riveter	17-ft. Bement
93 Shaper	24-in.	Cincinnati	191 Bending Rolls	14-ft. Niles
94 Shaper	24-in.	Cincinnati	192 Rotary Bevel Shear	Lenox
95 Vertical and Horiz. Milling Machine	No. 2	Beaman & Smith	194 Hydraulic Punch	60-in. Bement
96 Boring Mill	37-in.	Putnam	195 Hydraulic Shear	54-in. Bement
97 Boring Mill	37-in.	Cincinnati	196 Hydraulic Die Block Punch	36-in. Bement
98 Swing Gap Lathe	58 in.x27 in.x 12 ft.	Aurora	197 Hydraulic Punch	25-in. Bement
99 Shaper	24-in.	Lodge & Shipley	198 Hydraulic Angle Shear	Bement
100 Drill Press	40-in.		199 Hydraulic Universal Shear	Bement
102 Engine Lathe	20 in.x10 ft.		200 Hydraulic Horiz. Flange Punch	Bement
103 Vertical Milling Machine	No. 5	Becker	201 Quick-Acting Hydraulic Punch	20-in. Niles
104 Shaper	24-in.	Cincinnati	202 Bending Rolls	86-in. Niles
105 Screw Machine	2 in.x24 in.	Jones & Lamson	203 Power Punch with Spacing Table	28-ft. Niles & Jones
106 Drill Press	21-in.	Hoefler	204 Drill Press	40-in. Aurora
108 Universal Grinding Machine	No. 1	Bement	205 Drill Press	25-in. Hoefler
110 Crank Planer	24-in.	Cincinnati	206 Drill Press	21-in. Hoefler
111 Compound Shaper	28 in.x8 ft.		207 Drill Press	21-in. Hoefler
112 Compound Shaper	28 in.x8 ft.		208 Radial Drill with Tapping Atch	60-in. Niles
113 Shaper	24-in.		209 Hydraulic Flanging Press, Sectional	Bement
114 Drill Press	21-in.		210 Flue Welder	Ferguson
115 Engine Lathe	24 in.x12 ft.		211 Flue Welder	Ferguson
117 Drill Press	21-in.	Hoefler	212 Four Spindle Flue Sheet Drill	Niles
118 Drill Press	21-in.	Hoefler	213 Bolt Cutter	4-in. Acme
119 Engine Lathe	16 in.x6 ft.	Lodge & Shipley	214 Triple Bolt Cutter	1-in. Acme
120 Tool Room Lathe	14 in.x6 ft.	Pratt & Whitney	215 Double Bolt Cutter	1½-in. Acme
121 Tool Room Lathe	14 in.x6 ft.	Gould & Eberhart	173 Six Spindle Arch Bar Drill	Niles
122 Shaper	16-in.		176 Forging Hammer	200 lbs. Bradley
123 Planer	24 in.x24 in.x5 ft.		177 Forging Hammer	200 lbs. Bradley
124 Universal Tool Grinder		Horton	178 Forging Hammer	200 lbs. Bradley
125 Universal Milling Machine	No. 3	Hendey	181 Bolt Header	1-in. Ajax
126 Twist Drill Grinder		Yankee	182 Bolt Header	
128 Tool Grinder	21-in.	Gisholt	216 Hydraulic Bar Shears	2-ft. diam. Bement
129 Drill Press	21-in.	Hoefler	217 Double Bolt Cutter	1½-in. Acme
130 Frict'n Drill Press		Barnes	218 Bolt Pointer	Acme
131 Tool Room Lathe	10 in.x5 ft.	Pratt & Whitney	219 Forging Machine	No. 3 Acme
132 Universal Grinder	No. 1		220 Long Stroke Steam Hammer	1,600 lb. Chambersburg
133 Double Wet Grinder for Tool	No. 2	Springfield	221 Single Stand Steam Hammer	1,500 lb. Chambersburg
134 Brass Tur. Lathe	24 in.x8 ft.		222 Single Stand Steam Hammer	1,500 lb. Chambersburg
137 Sq. Arbor Lathe	15 in.x6 ft.		223 Hydraulic Bar Shears	1¼ in.x12 in. Bement
138 Sq. Arbor Lathe	15 in.x6 ft.		224 Hydraulic Punch and Shear	20-in. Bement
139 Brass Lathe	17 in.x6 ft.		225 Bolt Header	1½-in. Acme
140 Brass Tur. Lathe	17 in.x6 ft.		226 Cold Saw	Hegley-Cambria
141 Brass Tur. Lathe	18½ in.x6 ft.		227 Double Stand Steam Hammer	5,000 lb.
142 Brass Tur. Lathe	18½ in.x6 ft.		228 Single Stand Steam Hammer	1,100 lb.
143 Valve Milling Machine	No. 1	American	229 Single Stand Steam Hammer	1,000 lb.
144 Engine Lathe	28 in.x12 ft.		230 Double Staybolt Cutter	1½-in.
145 Engine Lathe	22 in.x10 ft.		231 Double Staybolt Cutter	1½-in.
146 Frict'n Drill Press		Barnes	232 Hammer Riveter	84-in. Allen
147 Drill Press	32-in.	Aurora	233 Portable Mud Ring Riveter	Pedrick & Ayer
148 Drill Press	21-in.	Hoefler	234 Portable Pneumatic Riveter	Pedrick & Ayer
150 Drill Press	21-in.	Hoefler	173 Six Spindle Arch Bar Drill	
151 Oil Separator	No. 1	American	181 Bolt Header	1-in. Ajax
152 Two-spindle Centering Machine		Whiton	182 Bolt Header	1-in. Ajax
154 Buffing Lathe	No. 3			
156 Planer Grinder	26-in.	Landis		
158 Engine Lathe	14 in.x6 ft.	Lodge & Shipley		
159 Disk Grinder	No. 6	Norton		
160 Turret Lathe	2 in.x26 in.	Pratt & Whitney		
161 Turret Lathe	2 in.x26 in.	Pratt & Whitney		
162 Turret Lathe, Glsholt	21-in.	Hoefler		
163 Drill Press	21-in.	Hoefler		
165 Bolt Lathe	14 in.x5 ft.	Bradford		
168 Drill Press	25-in.	Hoefler		
171 Frict'n Drill Press		Barnes		
174 Boring Mill	60-in.	Niles		
175 Drill Press	50-in.	Niles		
179 Radial Drill	72-in.			
180 Radial Drill	72-in.			
235-240 Double Emery Wheel Grinders	No. 6	Diamond		

